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OCTOBER 1917

FORMERLY THE S.A.E. BULLETIN

SOCIETY OF AUTOMOTIVE ENGINEERS INC.

29 WEST 39TH STREET NEW YORK

PHONE WAVERLY 1323
TELEGRAMS
FERGUS MOTORS
NEWARK

FERGUS MOTORS (OF AMERICA) INC.
370 JELLIFF AVENUE
NEWARK, N. J.
U. S. A.

FOREIGN OFFICE & WORKS
J. B. FERGUSON, LTD.
BELFAST.
IRELAND

Friday Sept. 14, 1917

American Bronze Company
Berwyn, Pennsylvania

Attention of Mr. V. W. Dow

Gentlemen:

Replying to your letter of September 7th, asking us for information as to the uses of Non-Gran Bronze in the Fergus Motor, we can give you the following:

Rear axle drive is through a torque tube carrying a ball end where it attaches to the cross member. The front and back half of the bearing for this torque tube ball is Non-Gran.

The camshaft is overhead. First bearing immediately back of the camshaft spiral bevel gear is Non-Gran.

The bearings carrying the spiral bevel gears at the top and bottom of the vertical shaft are Non-Gran.

The Magneto and pump cross shaft bearings, two in number, are Non-Gran.

The Universal joint rings are Non-Gran.

There are two Non-Gran bushings in the steering gear.

There are three Non-Gran bushes in the electric starting motor drive.

Tire pump connecting rod is a tubular affair made out of Non-Gran. There are two Non-Gran bushings holding up the tire pump shaft.

The generator idler gear is mounted on two Non-Gran bushings.

Speedometer front and rear drive gear bushings are mounted on Non-Gran.

Clutch gear bushing is Non-Gran as is also the clutch shaft pilot bearing.

We are inclosing under separate cover, six copies of the "Autocar" describing in detail the Irish Fergus Car, the essential features of which have been maintained in the American Fergus Car.

We appreciate very much the attitude that your Company has maintained toward us and wish to have it continue so.

Yours very truly

FERGUS MOTORS, INC.

V. W. Moncrieff

VIM/BEW

THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

Vol. I October, 1917 No. 4

The AERONAUTIC STANDARDS MEETING AT WASHINGTON

SPEED with accuracy is the most important factor at present in the formulation of aeronautic standards. This was forcibly brought out by Chairman Howard E. Coffin of the Aircraft Production Board at a meeting held Sept. 30 and Oct. 1 at the Bureau of Standards under the auspices of the Aeronautic Division of the Standards Committee, with Chairman Charles M. Manly of the Division presiding.

More than 75 engineers and aeronautic experts representing the United States Army and Navy, the Aviation Services of England, Canada, France and Italy, and American manufacturers of aircraft and of parts and materials entering into the final product, met with the members of the Aeronautic Division and of the International Aircraft Standards Board.

The first session was called to order Sept. 30 by S. A. E. General Manager Coker F. Clarkson, who stated that the purpose of the meeting was to give final consideration to a number of aircraft subjects, recommendations for which had been formulated by the Aeronautic Division. He then called on Chairman Coffin of the Aircraft Board, who called attention to the fact that international standardization is really being made a fact through the requirements of the aircraft industry. Mr. Coffin urged all the engineers and manufacturers in the aircraft industry to work together in preparing standards so that the deliveries of materials and of finished products would be adequate for military needs. (The remarks made by Mr. Coffin are given in full in this issue.)

The meeting then broke up into committees for the consideration of specific subjects. The remainder of the day, with intermission for luncheon served at the Bureau, was taken up by conferences of these committees. At the second day's session the reports of committees were considered. These related to such subjects as specifications for dope and varnish, engine-testing forms, engine-weight specifications, glue specifications, pontoon fittings, hose for radiator and jacket connections, safety belts, screws and bolts and washers, spark-plug shells, streamline tension wire, tachometer connections, wheel parts and wing attachments.

A number of the committee reports presented are given on page 271 of this issue. Some of them are in the nature of progress reports, but they are indicative of the wide range of the work to be done in aeronautic standardization. The various committees are at work during October and it is expected that a large number of subjects will be ready for action at the meeting of the Aeronautic Division to be held Oct. 28 and 29 in Washington.

The work of formulating specifications for dope and varnish is especially important in view of the fact that manufacturers at present have little information regarding these products. The report of the committee on dope recommends that two coats of acetate dope be substituted for the spar varnish on training machines. The report then goes on to give requirements for the testing and chemical composition of the dope to be used.

In the discussion of this report it was suggested that an 18-in. frame be used for the exposure test instead of the 12-in. size recommended by the committee. The larger size is thought desirable because it has been used to a considerable extent and data are available showing the effect the various dopes have on fabrics stretched over the test frame.

Dopes containing tetrachlorethane are not acceptable according to the report. S. G. Payne of the British Aeronautic Supply Department objected to this on the ground that a chemical constituent can be added to stop the action of the fumes in dopes containing tetrachlorethane, thus preventing injury to the men who are handling the dope. The advantage of such dope is that the fabrics coated have more flexibility. Mr. Payne also suggested that the specification should go more into detail as regards acetone, benzol, trichenol phosphate and other solvents.

In answer to this, Doctor Smith, chairman of the committee on dope, stated that the clauses limiting the acidity rendered detail specifications for solvents unnecessary. At a later date, however, it is planned to formulate specifications for the individual ingredients. The object of the present report is to prepare a specification that will give the manufacturer something definite. Later, clauses will probably be added relating to the humidity and temperature control necessary for the application of the dope and also to the modifications required to obtain color effects.

The committee on varnish recommends a clear and transparent material to be used to cover dope on the top of wings and for spars, propellers and other wooden parts.

There was considerable discussion as to the advisability of having a standard sample of varnish on hand, this to be compared with a sample of the material purchased by

means of exposure tests. Doctor Walker, chairman of the varnish committee, stated that exposure tests made at the Bureau of Standards led him to believe that varnish not deteriorating after three months was satisfactory. A laboratory test is provided for in the present specification and it is thought that varnish that will pass this test will be satisfactory as regards exposure.

Several days are required to make the varnish tests, and it was agreed that they could best be made at the plant where the varnish is manufactured. The Government inspector could sample large batches of varnish and after testing the sample the varnish could be sealed and applied on Government orders. This method of testing would save considerable shipping back and forth of any rejected material.

A protective varnish containing a color pigment has been found desirable in England for re-doping the tops of wings, this being needed to stop the action of light. It was said that pigments are mixed with transparent varnishes to give enamels of khaki, bluish gray and other tints required. While this effect can be obtained by adding pigments to the dope, it seemed more satisfactory to obtain the effect by using enamels as mentioned.

It is sometimes necessary to remove varnish from wings in order to re-dope them. The suggestion was therefore made that a solvent should be specified for removing varnish. If varnish could be removed by such a solvent, wings out of service for some time could be stretched and used again.

The report of the committee on varnish has been sent to manufacturers interested for comment and also to obtain data so that a recommendation can be made as to the use of colors for enamels.

The report submitted on glue specifications covers all glue to be used for propeller construction and for splices of important structural members such as longerons and beams. The quality, tests and general properties of the glue are specified; glue test-specimens for single shear, double shear and tension are described. The glue called for in this specification is not intended for veneers.

It was suggested that some scientific form of jelly strength test be formulated instead of the finger method. One way might be to have a cylinder of standard dimensions applied with a given force, the penetration resulting to be measured.

A sample of safety belt was submitted by the Navy Department for criticism. A different design is used by the U. S. Army so that there is a possibility of standardizing such belts. The straps used on the Navy belt is of leather and it was said it would be safer to use elastic webbing because leather gives way suddenly, while the webbing usually gives warning before failure. The stitching should be eliminated from such belts as far as possible. Copper rivets might be used to fasten the straps to the belt, pieces of leather being inserted on both sides of the webbing through which the rivets might be driven. It was decided to procure a sample of the belt now used by the Army and also one used by the British Royal Flying Corps before coming to a definite decision.

The committee on wheels, rims, spokes, and related subjects recommended that No. 1020 carbon steel be used for rims of airplane wheels. This steel was objected to on the grounds that rims of 0.18 carbon had failed at ten or eleven thousand pounds load, whereas those made of 0.26 carbon steel had sustained the loads of fifteen or sixteen thousand pounds before failure. On the other hand, the higher carbon steel rim has given trouble in forming the seat for the spoke-nipples. The hardness of such steel is to be investigated, as is also the design of spokes and nipples for American and English practice, a definite recommendation on the subject to be made at the next meeting of the Aeronautic Division. (A committee meeting to consider this subject was held Oct. 19 at Washington.)

Both round and square bevel washers are suggested for standardization by the committee on screws, bolts and washers. The square bevel washer is considered preferable from the manufacturing standpoint. This committee has also suggested that 9/16 and 5/8-in. sizes be added to a plain and ball hex bolts and to the ball castle and flat bottom castle nuts previously standardized.

Tentative dimensions for eyebolts were submitted, and it was suggested that the head diameters vary by sixteenth instead of by thirty-second inches. It is unusual to find cold-drawn stock varying by thirty-seconds of an inch, and unless it is necessary to machine the entire circumference of the head, it is not necessary to use such sizes. The consensus of opinion at the meeting was that the 1/16-in. variation would be satisfactory.

Complete engine-weight specification forms were presented for consideration, the purpose of these being to give a definite meaning to the weight per brake horsepower used in comparing aviation-engine performance. These specifications cover general data relating to the type of engine, the horsepower under various conditions, and the weight of all important parts connected with the engine. There was no comment upon the report at the meeting, and it will therefore be submitted for final action at the next meeting of the Aeronautic Division. Meanwhile it is intended to send out preliminary copies in order to obtain constructive criticism.

A hex size of 1 in. was recommended for spark-plug shells, the foreign metric hex being very near to this. A minimum dimension of 3/32 in. from the bottom of the thread chamfer to the bottom of the shell was suggested. This is desired so that the thread will enter the cylinder easily. The committee on this subject will collect more information regarding British and Italian standards, so that a final report can be submitted at a meeting of the Division.

Chairman Manly said it was necessary to find a rubber hose that would be suitable for gasoline and oil requirements. He also desired to learn of a method of test so that the samples submitted could be tried out without actually putting them on a machine, the latter method being expensive and difficult to carry out.

John B. Tuttle of the Bureau of Standards submitted a report on the subject, and said that a conference of manufacturers of the different types of tubing might result in specifications being prepared for the right product. It was also said that airplane manufacturers should take part in such a conference because they were familiar with the requirements and actual use.

Mr. Tuttle mentioned a scheme that is being tried of coating the inside of rubber tubing to resist the action of the gasoline. Shellac has been used for this purpose but has been found hard to apply and to dry. The plan is promising, however, and further experiments will be made. The rubber tubing that was available in this country did not comply with the British specifications, but manufacturers and the Bureau of Standards have improved the product.

A meeting of those interested in rubber tubing is to be held at the office of the Goodyear Tire and Rubber Co., Akron, Ohio, on Oct. 26, in order to formulate a specification that will insure at least as good quality a product as that called for in the British specifications and

also one that can be made in this country and delivered in any quantity required.

Standards Manager M. W. Hanks reported that a flexible metal union is being developed for use with copper or brass tubing. It was hoped to find a type of union that will not lead to breakage of the rigid tubing.

A number of other subjects were mentioned as being under consideration by the Division. Connections for streamline wires are being studied. The method of winding safety wires on turnbuckles is being considered. The committee on pontoon fittings reported that standardization is not advisable at the present time for dimensions of handholes, toeing cleats and drain plugs. The committee recommends that manufacturers try out different types of construction with a view to formulating standards as soon as possible. Practically the same attitude was taken by the committee on wing attachments. It is thought that the idea of standardizing spacing of wing beams for various chords be dropped at the present time because the work is too closely connected with individual design. The consideration of wing attachments should be discontinued for a time for the same reason. Chairman Manly advocated action of some sort in order to make a start. He said that it might be possible to standardize the hole-dimension in the hinge pin and that this might be followed by the formulation of standard dimensions for the head and body of the pin, even if the length could not be settled upon. The committee on tachometer drive has practically completed its work and is finishing the drawings and specifications.

ATTENDANCE AT AERONAUTIC MEETING

ABETTI, CARLO, captain, Italian Aviation Service, *Washington, D. C.*

ASPINWALL, FREDERICK P., senior inspector of dopes, Signal Corps, U. S. A., *Washington, D. C.*

ATKINS, A. K., lieutenant-commander, Bureau of Steam Engineering, Navy Department, *Washington, D. C.*

AUSTEN, LEWIS H., Perry-Austen Mfg. Co., *New York.*

BLOOD, HOWARD E., lieutenant, Signal Corps, U. S. A., *Washington, D. C.*

CALDWELL, F. W., Signal Corps, *Washington, D. C.*

CAUTLEY, JOHN R., Wright-Martin Aircraft Corp., *Washington, D. C.*

CESTONI, FELICE, lieutenant, Italian Aviation Service, *Washington, D. C.*

CHASE, HERBERT, assistant secretary, S. A. E., *Washington, D. C.*

CHAUVEAU, ROGER, Signal Corps, U. S. A., *Washington, D. C.*

CLARKSON, COKER F., general manager, S. A. E., *Washington, D. C.*

COFFIN, H. E., chairman, Aircraft Production Board, *Washington, D. C.*

CRANE, JASPER E., E. I. du Pont de Nemours Co., *Wilmington, Del.*

DAVIS, JAMES W., The Burgess Co., *Marblehead, Mass.*

DE CHANVALON, E. C. THIBAULT, captain, French Aviation Commission, *Washington, D. C.*

DICKINSON, H. C., Bureau of Standards, *Washington, D. C.*

DUFFIN, F. G., chairman, International Aircraft Standards Board, *Washington, D. C.*

DOERFLINGER, WM. F., Perry-Austen Mfg. Co., *New York.*

DUESENBERG, F. S., Duesenberg Motors Corp., *Elizabeth, N. J.*

EHRMAN, E. H., Chicago Screw Co., *Chicago.*

GEORGER, EDWIN L., Pratt & Lambert Co., *Buffalo.*

GORMULLY, A. R., F. I. A. T., *Washington, D. C.*

GRAY, B. D., inspection and specifications, Signal Corps, U. S. A., *Washington, D. C.*

GRISWOLD, ELY, Griswold Mfg. Co., *Erie, Pa.*

HALE, J. E., Goodyear Tire & Rubber Co., *Akron, Ohio.*

HANKS, M. W., standards manager, S. A. E., *New York.*

HARRIMAN, DANIEL F., Wright-Martin Aircraft Corp., *New York.*

HEATH, SPENCER, American Propeller & Mfg. Co., *Baltimore, Md.*

HELDT, P. M., Class Journal Co., *New York.*

HERZ, F. W., National Varnish Co., *Long Island City, N. Y.*

HILL, W. H., Equipment Division, Signal Corps, U. S. A., *Washington, D. C.*

HUFF, THOMAS H., Standard Aero Corp., *Plainfield, N. J.*

HUNSAKER, J. C., naval constructor, Bureau of Construction and Repair, Navy Department, *Washington, D. C.*

HUNTINGTON, HOWARD, Huntington Aircraft Co., *Princeton, N. J.*

JOHNSON, J. B., equipment division, Signal Corps, Plane Design Section.

KING, CHARLES B., Signal Corps, U. S. A., *Washington, D. C.*

LANE, FRED H., Emil Culman & Co., *New York*

LIBBY, A. D. T., Splitdorf Electric Co., *Newark, N. J.*

LOENING, G. C., Loening Aeronautical Engineering Corp., *Long Island City, N. Y.*

MACGREGOR, International Aircraft Standards Board, *Washington, D. C.*

MCLAUGHLIN, C. D., Signal Corps, U. S. A., *Buffalo.*

MCISAAC, HUGH, U. S. Aero Corp. of California, *Washington, D. C.*

MANLY, CHARLES M., Curtiss Aeroplane Co., *Buffalo.*

MARMON, HOWARD, captain, Signal Corps, *Washington, D. C.*

MASON, CARL T., Splitdorf Electric Co., *Newark, N. J.*

MERICA, PAUL D., Bureau of Standards, *Washington, D. C.*

MIGNOT, U., lieutenant, French Aviation Commission, *New York.*

MONTGOMERY, STAFFORD, captain, Signal Corps, U. S. A., *Washington, D. C.*

MOOSMANN, J. J., Dupont Chemical Works, *New York.*

MORSE, F. L., Thomas-Morse Aircraft Corp., *Ithaca, N. Y.*

MORTON, H. E., B. F. Sturtevant Co., *Boston, Mass.*

NORRIS, G. L., International Aircraft Standards Board, *Washington, D. C.*

OAKLEAF, HOWARD B., Signal Corps, U. S. A., *Washington, D. C.*

PAGE, S. H., Union Gas Engine Co., *San Francisco.*

PAYNE, S. G., British Aeronautic Supply Department, *Buffalo.*

PENNEWILL, E. E., Standard Aero. Corp., *Plainfield, N. J.*

PIERSON, JOHN A., Wright-Martin Aviation Corp., *New York.*

PLIMPTON, R. E., publication manager, S. A. E., *New York.*

PRENTISS, W. F., lieutenant, British War Mission, *Washington, D. C.*

PULSIFER, LAWSON VALENTINE, Valentine Co., *New York.*

RIDDELL, M. R., Canadian Aeroplanes, Ltd., *Toronto, Can.*

ROHDE, O. C., Champion Spark Plug Co., *Toledo, Ohio.*

SLOANE, J. E., Signal Corps, U. S. A., *Washington, D. C.*

SMITH, W. H., Bureau of Standards, *Washington, D. C.*

SPEAR, G. B., chief of gage design, Signal Corps, *Washington, D. C.*

STEFANO, D'AMICO, lieutenant, Italian Aviation Service, *Washington, D. C.*

SULLIVAN, CARL E., chief inspector of instruments, Signal Corps, U. S. A., *Washington, D. C.*

THELEN, ROLF, forest service, U. S. Department of Agriculture, *Washington, D. C.*

TUTTLE, JOHN B., Bureau of Standards, *Washington, D. C.*

VEZZANI, FERRUCCIO, lieutenant, Italian Aviation Service, *Washington, D. C.*

VINCENT, J. G., major, Signal Corps, U. S. A., *Washington, D. C.*

WALKER, PERCY H., Bureau of Standards, *Washington, D. C.*

WATERBURY, J. H., Pratt and Lambert, *Buffalo.*

WILLARD, CHAS. F., Aeromarine Plane and Motor Co., *New York.*

WOOLSON, L. M., lieutenant, Signal Corps, U. S. A., *Washington, D. C.*

WYSONG, O. C., Wysong-Miles Co., *Greensboro, N. C.*

Demands of Aircraft Standardization

By Past-President Howard E. Coffin

THE men who are building aircraft or who are engaged in the production of materials involved in the manufacture of aircraft are pretty busy nowadays, and are apt to feel that they are entirely too busy to attend meetings in Washington pertaining to things which have no particular bearing upon their work of to-morrow or of next week. It has been hard to get action upon many things that must have the attention of the men who are themselves engaged in the industry and whose experience, therefore, is the experience which must go to determine the best practice, the best average practice as regards construction or materials.

If this war were to end in a couple of months, that might be a logical attitude of mind for the men who are engaged in the work of production of aircraft and aircraft materials; but inasmuch as instead of being a period of months, it is clear that it is a question of a period of years, it is absolutely essential that the fundamental work which will ultimately increase the productive capacity of the country—the productive capacity not only of this country but of the Allied countries—must have our earnest attention.

The determination of standards, both of a domestic and of an international character, will sooner or later fix the quantity production in the various countries. For instance, we have in this country now the spectacle of our industries being called upon for the quantity production of aircraft materials for all of the other Allied powers.

The orders coming to us for these materials run throughout the entire scale of specifications for steel, lumber and other commodities. The industries of this country cannot hope to meet the requirements of the situation upon anything like such a quantity basis as they could if the specifications were standardized in accordance with the considerations of the Aeronautic Division of the S. A. E. Standards Committee in cooperation with all those interested in the aircraft program.

I think none of us questions the vital part that the aircraft development is going to play in settling the war. We have seen during the last three months the advancing importance of aircraft in every sort of military and naval operation. The belief is rapidly growing, not only in this country but in foreign countries, that the domination of the air will be the decisive factor in the settlement of the conflict. By domination of the air I do not mean the domination of the fighting line itself, simply through the use of high-speed fighting craft, but the domination of the air over the countries, behind the lines, through the use of long-distance bombing machines—machines of far greater size perhaps than any of us even now conceive to be probable. Machines are being made in the various countries that are much larger than anything now in existence. We already have machines such as our Italian friends have brought to us, fitted with engines of a thousand horsepower and capable of carrying twenty-five or thirty men or several tons of explosives. Those machines are handled just as smoothly and easily as the little two-seated training plane with which we are more familiar in this country.

In short, there seems to be little limit to what can be done in the air. I have never seen more conclusive evidence of this than that given by one of the big flying-boats equipped with engines of some four or five hundred horsepower and with the weight of an ordinary speed launch, a boat some fifty feet long and with all of the appearance of a fair-sized gasoline-driven yacht, capable of housing in the cabin probably five or ten men.

The impressive thing about the matter is that this boat might be driven through the water by its engines at possibly thirty-five miles an hour as a maximum, and yet the same horsepower, when applied through air propellers and wings, picks the boat out of the water and carries it at a speed of ninety miles an hour through the air.

Such a performance makes us wonder just where the limit is. If we can apply the power through multiple units and through the attachment of wings, either in biplane or triplane form, there is little to prevent our doing much better with boats of the air than with boats restricted to use on water. This is most important when we consider that the great backbone of the enemy's campaign lies in the submarine and that the flying-boat is probably the most conclusive answer to it.

It is not possible for me to deal with the exact program for the production of aircraft in this country. There are military and naval reasons why this information should not be given in detail, but I can state that the program upon which we are engaged unquestionably will be greatly increased. The demands from every one of the Allied countries are being concentrated here, and are indicative that sooner or later the construction of aircraft in all the nations engaged will be limited simply by their productive capacities.

Many materials cannot be obtained in sufficient quantities to meet the programs which are being planned, consequently there must be substitutions in these materials. This matter of substitution is a question for engineers to study. Standardization in both design and specification of materials is an engineers' problem and a manufacturers' problem. The military and naval authorities are interested in obtaining the delivery of aircraft in sufficient quantities to meet the needs of the situation and of sufficient quality that they may be safe instruments of war in the hands of military and naval pilots. But the great problem of standardization in both designs and specifications of materials is first and foremost the manufacturers' problem, the engineers' problem, because they, after all, must deal with these materials, must obtain deliveries of these materials and must meet the needs of the Government in both branches of the service.

We cannot always understand why it is more essential for us to come to Washington to sit on committees and decide on the specifications for steel or the specifications for spruce, than it is for us to stay at home and

From address delivered by the Chairman of the Aircraft Production Board at the Aeronautic Standards Meeting in Washington.

work along on the making of aircraft. But within six months' time the standardization work proposed will begin to be felt in the industry. We will then find that the deliveries of material will become easier and that the uniformity of design and in specification has gone far toward increasing the quantity production in every line of this work.

The standardization work in the long run is the most important thing that we can do to facilitate the consummation of the military and naval programs, not only in this country, but in the European countries as well. This work to be first attended to is a matter of domestic standardization—a matter of our own internal bookkeeping—but from that point it must go on and is going on now into every one of the Allied countries. In this aircraft art I think that we will see brought about for the first time in history a real standardization of design, mechanical practice and specification between a large number of the countries of the world.

We have been discussing international standards for years—the metric system, standard weights and measures and a great many other things—but so far as the actual achievement of results has gone we have made very little progress. Here is a situation where we are driven by the actual necessities of the war to get action, not only on this side of the Atlantic, but in the foreign countries as well. We are meeting with the most cordial reception in taking up this work. The countries of Europe, realizing that they must depend upon this country for the supply of great quantities of materials, and that this supply can be augmented if the demands made on us are standardized, are sending their representatives here to work out these problems for the benefit of the common cause.

Speed is the essence of this situation, and with the prospect before us of a gigantic program of aircraft construction, both in military and the naval branches of the service, and with the vastly increased programs which are going forward in the foreign countries, the standardization work is of the most vital importance.

Our troops will need aircraft in quantities for the spring campaign, and we believe ample provisions are being made in this country and in Italy, France and England for the construction and delivery of such fighting craft as will take care easily of any forces that we have at the front up to July 1 of next year. At that time it is confidently hoped that the supply of such materials from this country will have reached a stage where there will be little dependence upon the foreign sources of supply.

If the shipping situation becomes more acute, it will be necessary of course to transport large quantities of standard parts manufactured in this country and large quantities of raw materials to be erected or fabricated as the case may be on foreign soil. There will be a great demand in this country for parts to go in machines that will be assembled abroad; here again is the necessity for standardization in many phases of the work. For the sheet-metal work, for steel, for specifications of all kinds, for scientific instruments connected with the air service and everywhere, we are confronted with the necessity for speed.

SECOND PAN-AMERICAN AERONAUTIC SHOW

THE Second Pan-American Aero Show, which will be held at the Grand Central Palace from Feb. 16 to 23, 1918, will be, it is believed, of special interest to automotive engineers. It will be remembered that an exhibit of S. A. E. standards was made at the Aeronautic Show last year, and it is probable that this will be repeated the coming year. The exhibit last year consisted mainly of standards developed for the automobile industry, but in view of the large amount of work done this year by the Aeronautic Division, there is opportunity for an exhibition of S. A. E. aeronautic standards.

The exhibitors at the show will consist of makers of airplanes and of airplane engines, parts, machinery, instruments and accessories. It will thus be possible for the members of the Society engaged in aeronautics to study each other's products and to discuss each other's experiments.

The show will, in the words of President Wilson, "stimulate recruiting and patriotic interest in the war, to the end that the utmost cooperation of all citizens in the successful prosecution of the war be secured."

Conferences on the possibility of using airplanes for commercial purposes will be held during the exposition. The chief of these will be a conference at which representatives of the different cities touched by the Woodrow Wilson Aerial Highway will discuss the program for the establishment of landing places every fifty miles along the aerial highway.

It is believed that manufacturers will be able to decrease cost of production and increase the quality of aircraft if they can see the possibility of a permanent demand for them after the war. The use of aircraft for mail and express carrying and similar purposes will therefore be discussed at length during the aeronautic show.

The governments of the Pan-American Republics have been invited to participate, and it is understood that all these will send representatives to the show. While it will not be possible to exhibit any machines or parts containing improvements, a knowledge of which would be useful to the enemy, still an effort will be made to show the American public everything possible about aircraft that can be revealed without giving valuable information to the enemy. In view of the extensive air program now being carried out by this country, it is believed that thousands of people will be interested in getting a first-hand view of the air apparatus. Augustus Post, 280 Madison Ave., New York, is secretary of the show.

New Aeronautical Laboratories

THE work the Bureau of Standards in Washington is doing in promoting scientific research is well illustrated by the recently completed low-pressure engine-testing laboratory. This laboratory was designed for the testing of airplane engines under conditions met with at high altitude, but it is also available for scientific research work of the Bureau whenever conditions of low pressure and low temperature are required.

The laboratory building has been practically completed, and the apparatus is so nearly installed that it is expected that testing work will be started in a few days. The location is at the west end of the Gage Standardization Building, which was shown in the layout of buildings on page 133, August issue of THE JOURNAL.

The outer building is a 24 by 50-ft. stucco structure. The vacuum chamber inside this is 6 by 6½ by 15 ft. high, with a wall 12 in. thick, made of concrete reinforced with steel and lined with cork.

The air passing into the chamber can be controlled by hand and automatic throttle valves, so that its pressure ranges from atmospheric down to about one-half an atmosphere, or the equivalent of the pressure at an altitude of 20,000 ft., and can be precooled to temperatures approximating those occurring at that altitude. It will be possible thus to approximate actual operating conditions over a wide range.

The exhaust from the engine will be piped into a chamber outside the test compartment, this being kept at low pressure by means of a large rotary exhaust blower, which also withdraws air from the test chamber itself. The exhaust is cooled by water injection before passing to the blower.

The refrigerating system consists of a large machine of the ammonia type of 25 tons' capacity, belt-driven by a 40-hp. electric motor. Large refrigerating coils are placed both in the vacuum chamber and in the outer room, so that the air passing into the chamber can be cooled as much as is desired. In order to cool the air it is first drawn through the coils outside the chamber, and when inside the vacuum chamber it can be piped directly to the carbureter or led to the interior and allowed to find its way through the carbureter.

The air inside the chamber is circulated by fans driven by electric motors, one object of this circulation being to attain high air velocity over the engines and another to carry away the heat radiated from the engine and exhaust manifolds and absorb it in the refrigerating coils inside the chamber. After the air is cooled while passing through these coils, it is again circulated over the engines.

The exhaust from the engines is led into water-jacketed pipes, connected with the individual cylinder exhausts. Water in turn is led directly into this water-jacketed pipe in order to cool the exhaust. These pipes from the cylinder exhaust lead to headers, which in turn are connected to tanks outside the vacuum chamber. The tanks serve to eliminate pulsations from the exhaust. The exhaust is then led to the vacuum pump located in the outer chamber. The water flowing out with the exhaust is siphoned out when the mixture passes through the vacuum tanks.

The engine to be tested will be placed inside the vacuum chamber, being mounted on supports similar to those used in aircraft. An electric dynamometer with control mechanism is located in the outer chamber. This dynamometer has a normal rating of 300 hp., with a 30 per cent overload capacity.

It is expected that it will be possible in this new laboratory to control absolutely the temperature and pressure conditions in the vacuum chamber, thus enabling aviation engine performance to be practically duplicated under conditions when measurements can be made. Thermocouples can be placed at various points in the vacuum chamber and the indicating mechanism placed outside so that exact temperature readings can be taken at any time for almost any point in the engine. Different kinds of carbureters can be installed, so that their performance can be tested.

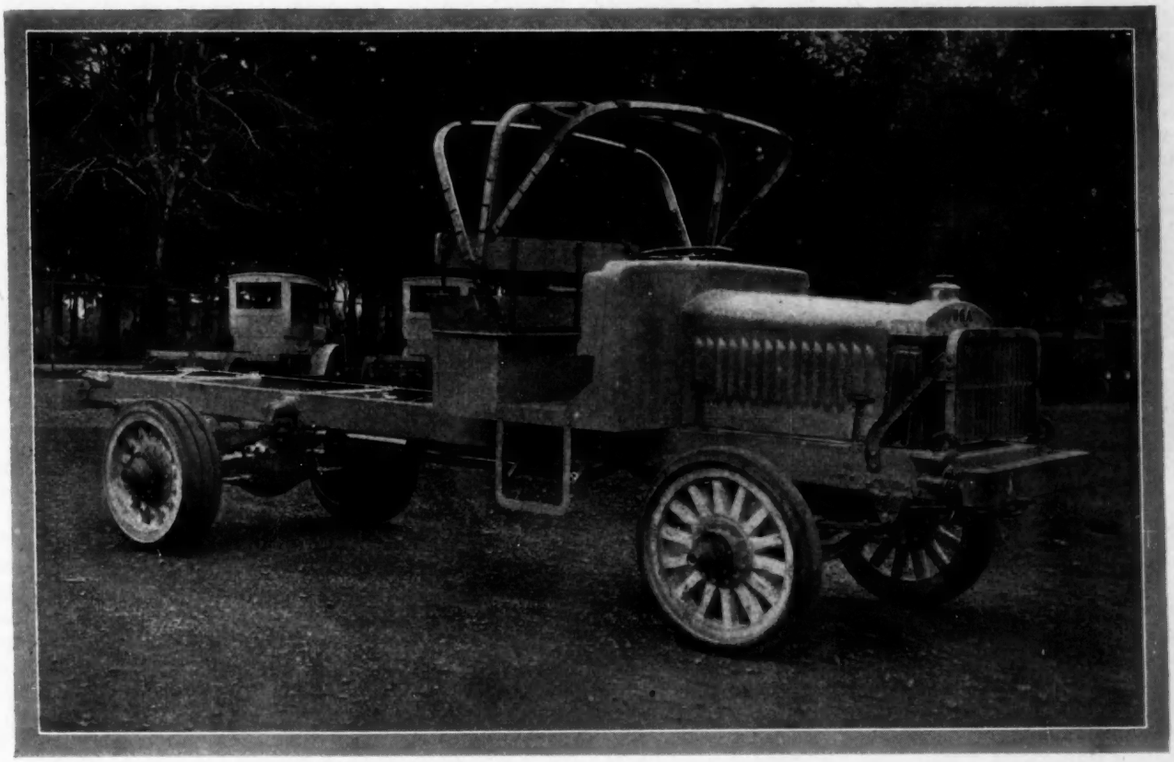
Provision is made for measuring amounts of air, fuel and water together with their temperatures, so that complete heat balances can be computed for all operating conditions. Adequate equipment for many other supplementary measurements, such as compression and explosion pressures and incidental pressures and temperature, have been provided.

Construction of Wind Tunnel

In connection with the design of airplanes, structural members and aeronautic instruments, as well as for many other purposes, experiments must be made in air at high velocities and under conditions which can be controlled. The usual method of performing such experiments is by means of the so-called wind tunnel or wind channel of suitable size and construction. Such an equipment requires a considerable amount of space and special apparatus.

The Bureau of Standards has had under consideration for several years the construction of a wind tunnel for general aeronautic experiments, but construction has not been undertaken until recently, as other problems have seemed to be of more immediate importance. Early in the summer plans were perfected for the construction of a special building to house a wind tunnel and a moderate amount of laboratory space to be used in connection with the wind-tunnel observations. This building, approximately two-thirds completed, is 90 ft. long, 30 ft. wide and 23 ft. high, and is of brick and stucco construction, the brick walls extending to the window sills. About 65 ft. of the length of this building to the full height is set aside for the housing of the wind tunnel proper. The remaining 25 ft. of length is divided into two stories with two small rooms on the first floor and a single drafting room on the second floor.

The wind tunnel is to be of open-end continuous type, constructed, however, so that it can be readily transformed into an Eiffel-type tunnel when desired. The wind channel will be 4 ft. in diameter and of octagon section, as the octagon section combines some of the advantages of both the square and circular type of construction. The air blast for the tunnel will be furnished by means of a conventional areonautic propeller directly connected to a 75-horsepower motor, and air velocities up to 60 or 70 miles an hour are expected. Comprehensive plans have been made for special wind-tunnel balances, which, it is hoped, will add materially to the accuracy and convenience of observations of this nature.



ONE OF THE FIRST COMPLETED CHASSIS OF THE HEAVY-DUTY UNITED STATES WAR TRUCKS

Acceptance of Military Trucks

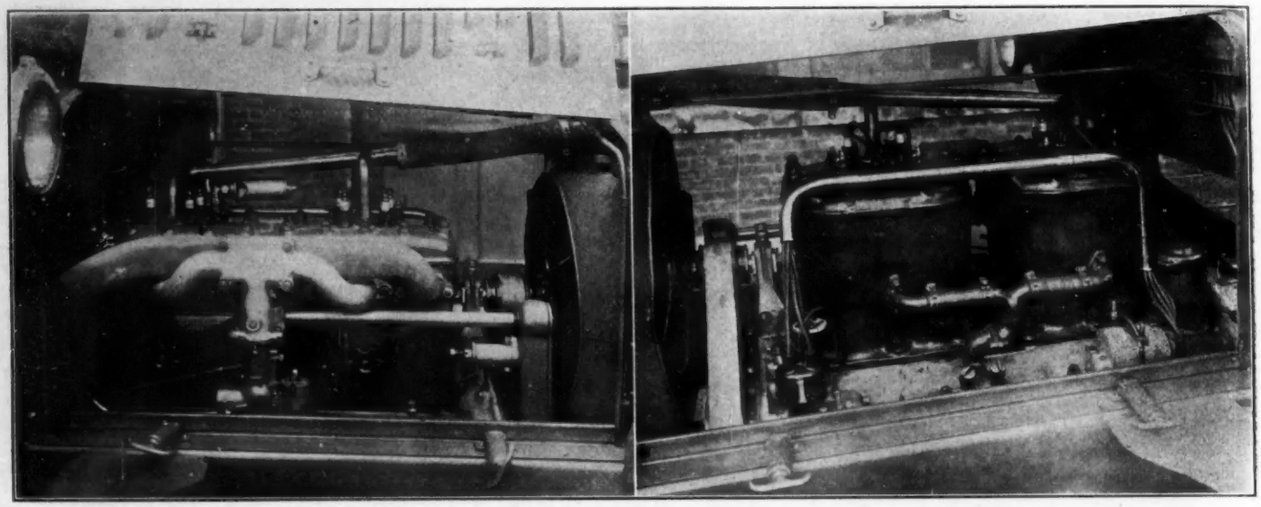
EDITORIAL CORRESPONDENCE *Illustrated by* PHOTOGRAPHS

THE first two heavy-duty (Class B) war trucks, designed by the Quartermaster Department with the assistance of a large group of automotive engineers, were officially accepted at noon Oct. 19 in Washington. The historic ceremony took place near the State, War and Navy Building in the presence of many Government officials and other invited guests. A. W. Copland, chairman of the Schedule Committee, which was responsible for securing the parts for and assembling these first two trucks, delivered them to Brig. Gen. Chauncey B. Baker of the Quartermaster Corps. He in turn delivered the trucks to the Hon. Newton D. Baker, Secretary of War, who received them on behalf of the Nation. Secretary Baker expressed his gratification at the concrete evidence that the new war trucks were a success, and predicted that they would be a vitally important factor in the advance of the American armies in France.

The affair was conducted under the auspices of the Motor Truck Committee of the Automotive Transport Section of the War Industries Board. The invited guests included President Wilson, the members of the Cabinet with their department heads, members of the Council of National Defense, War Industries Board, Aircraft Production Board and officers and engineers in the Military Transport Division, Quartermaster Corps, and also those connected with other branches of the army using motor trucks.

The two trucks thus presented to the Government had been driven to Washington over the roads from the factories in Rochester, N. Y., and Lima, Ohio, where they were assembled. The journeys required less than six days for completion, this including the time spent in hotels and in local demonstrations. In many cities the citizens turned out to welcome the trucks with parades. Both trucks successfully completed their trips, although they were driven over mountains and hills, for many miles through heavy red clay mud, hampered by wind and rain. Considerable driving was done at night over roads new to the drivers, but in spite of all difficulties the trucks emerged triumphant from their initial road tests.

The two trucks that have been assembled have exceeded the expectations of not only General Chauncey B. Baker of the Quartermaster Department, which has directed the work, but also of the two score of engineers and hundreds of draftsmen who worked on the design.



VIEWS OF 4¾ BY 6-IN. FOUR-CYLINDER ENGINE MOUNTED IN NEW MILITARY TRUCK

Early tests of the engine showed 58 hp. at 1350 r.p.m., and the engine torque curve is better than anticipated. It is now assured that the U. S. heavy-duty War Truck is one of the greatest engineering successes of the war, that it is destined to revolutionize army-truck work so far as operation and maintenance are concerned, and that the truck will play a large part in affecting truck design in commercial circles.

That the War Department, as well as the members of the Society who cooperated in the design work, are convinced that the truck is right, is shown by the fact that orders for 10,000 parts for the truck have already been placed, these orders including engines, axles and other parts. These orders have been widely placed over the industry, three or more different companies generally receiving orders for each of the different parts.

Any apprehensions as to the truck being too heavy for its carrying capacity have been dissipated by the statement of weights given by those companies building the units entering into the first machines. The maker who assembled the first truck states that the total weight of the chassis without body is 8500 lb., which with a 1600-lb. body will bring the total up to less than 10,000 lb. A few examples of weights as given by makers that have produced some of the parts indicate how well the engineers have worked, notwithstanding they were under orders to build a stout robust job suited to the extreme service of the war zone. The engine weighs 1012 lb. The rear axle weighs 1592 lb., with hubs and brake-drums; the front axle with hubs 352 lb.; the transmission 233 lb.; the clutch and case 103 lb.; the frame without castings 653 lb.; the front springs 148 lb., and the rear springs 544 lb. With different makers these weights vary from 40 to 50 lb. in such a case as the engine, and there are smaller variations with other parts. Without doubt weights of these parts taken after they are well in production will show many reductions in all of these figures.

Now that the War Truck, as it has been christened, is a reality, the work of the forty or more S. A. E. members who developed the design under the direction of Captain W. M. Britton, stands out in strong relief. The work of speedy cooperation that characterized the production of the Liberty aviation engine has been equalled in the case of the War Truck. In spite of the fact that a greater number of interests were involved in the building of the truck, making compromises in design more difficult, great unanimity of feeling among those participating makes the result the more remarkable, and if anything more unusual, than the performance of the relatively few engineers engaged in the case of the Liberty airplane engine.

Roughly there were four major divisions of the engineering work, those relating to the engine, the transmission, the axles and the other chassis parts. Each was manned by a corps of engineers. There were three, four and in some cases five different companies represented in the work on one unit, and it was necessary for the engineers to sink all personal pride and contribute the best known to the art. Each unit represents a composite of the best features contributed, rather than the work of any one individual. The engineer best qualified to design a certain part handled it in consultation with his fellow engineers. Considering the great amount of conference work, it is amazing that the truck has come through so rapidly; in short, it was unbelievable to many a month ago that the task could be accomplished. The impossible has come to pass, and a new chapter in war cooperation has been written.

The speed with which the different makers attacked their respective tasks and completed them is shown by the following:

The Continental Motor Mfg. Co., which was one of the several engine producers participating in the program, received blueprints on Sept. 9, and had an engine running within 19 days and 18 hours thereafter. The Waukesha Motor Co., after a flying start, had its first engine running within 11 days and 7½ hours from the time the blueprints reached its factory. These companies did not have to make all the patterns for castings or the dies for forgings, some of these having been made previously, but they had to do most of the machining and other operations on the parts. In developing the engine four or five makers cooperated by dividing the different parts between them, one making several parts not only for itself, but for the other engine makers. In this way much time was saved. The Continental company made the cylinders, gearcase cover and many small parts, such as pumps and bushings. The Waukesha company manufactured the cylinder heads, the crankcase, intake and

exhaust manifolds and roller push-rods. The Wisconsin company made the lower part of the crankcase.

The remarkable patriotic response of manufacturers of raw and finished products made possible the completion of the units in record time. As an illustration, the Park Drop Forge Co. worked continuously in three shifts and succeeded in sinking the dies for the crankshaft in seven days, an operation which is rarely completed in peace times in less than three weeks. The Werra Aluminum Castings Co. produced the pattern for the main crankcase and the first casting in five days, this usually taking from three to four weeks on much smaller jobs. The Continental pattern shop completed the pattern for the cylinder pairs in slightly over five days, an accomplishment which can be appreciated only by those who have manufactured engines.

UNITED STATES CLASS B WAR TRUCK. FROM PHOTOGRAPH TAKEN JUST OUTSIDE WASHINGTON

In summarizing the cooperative talent embodied in the engine, it might be said that the crankcase is Continental, the cylinders Waukesha, the oiling system a combination of Wisconsin and Buda, the pistons Hercules and the timing-gear system a combination of Buda, Wisconsin and Continental. The governor is a combination of Kelly-Springfield and Waukesha. The camshaft is a composite design. The engine has been designed with the thought of using the heavier fuels, the combustion chamber and other parts having been designed to meet these requirements.

What has been said of the engine can be said of the transmission, the axles, and other parts. Three or four of the leading axle makers have worked together on the axle designs. So with the transmission.

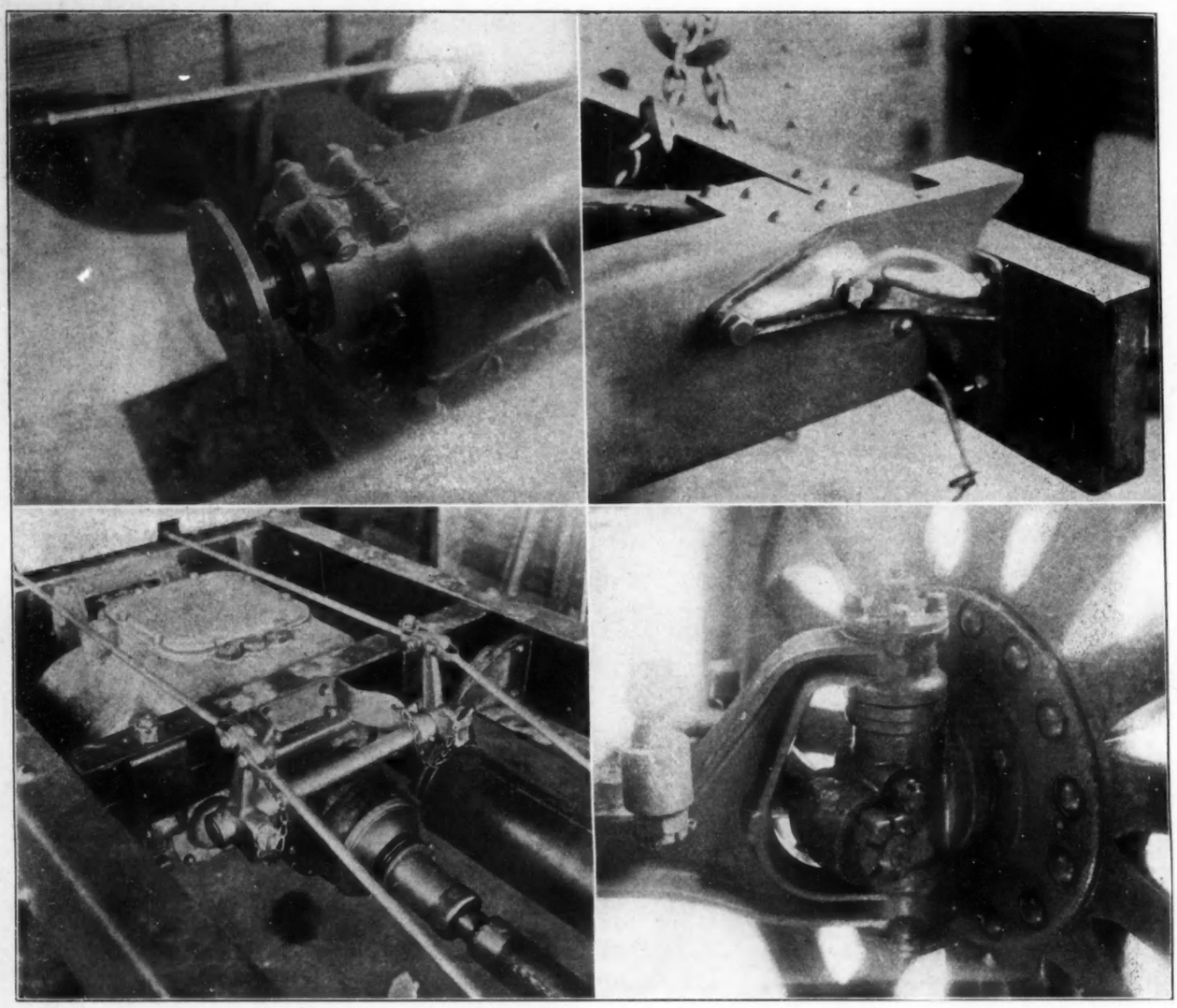
So well have all of the engineers cooperated that the schedule set for the completion of the different truck units, as well as of the completed truck, has been lived up to and generally improved upon. The first engines built in different factories were to have been delivered on Sept. 30, and they were delivered on that date. The completed chassis was to have been ready Oct. 10, and was ready on the seventh of October.

The spirit which has made possible the thousands of S. A. E. standards has arisen to the patriotic impulse and made possible this concrete instance of the development within very little more than a month's time of one of the most effective transportation units ever produced for the conduct of war. When the history of this war shall have been written, will not the outstanding facts be that the failure to take Paris within a month was due to the inability of the German transport system to follow the otherwise perfect organizations in other arms of the service, and that the battle of Verdun was won by the efficiency of American commercial trucks in furnishing this shell-torn stronghold with materials of war and food? And is it not entirely probable that the American forces in the field will be able to drive through to the final victory due entirely to the fact that their transport system had been standardized, and that when the final advance comes the American troops will be able to go forward supported on materials of war by the most efficient transportation system consisting of the motor trucks which have been herein described?

DETAILS OF DESIGN

A description of the Class B truck was given in the September issue of THE JOURNAL, but further details are now available, as well as photographs of the finished trucks and their components. The Automotive Products Section of the War Industries Board has supplied the following information for the benefit of S. A. E. members:

The engine is 4¾ by 6 in., or of 424 cu. in. capacity.



SHOWING IMPORTANT PARTS OF CLASS B WAR TRUCKS RECENTLY DELIVERED TO GOVERNMENT

The fuel is fed by gravity from a 15-gal. tank on the dashboard, there being a 16-gal. reserve tank under the seat. It is really a 5-ton truck, and will probably weigh in production 8000 lb. for the chassis with wheels and tires but without body.

Three points have been kept in mind in designing the engine: First, the best possible lubrication; second, the provision of a water jacket reaching every smallest point likely to become hot; and, third, rigidity without excessive weight. The cylinders are cast in pairs with detachable heads, each head being secured by thirteen ½-in. studs. The two spark-plugs are located side-by-side, with a water space between their bosses, in the center of each cylinder. The water-outlet pipe, which is built-up of brass, is offset enough to allow easy access to both plugs with a socket wrench. All the combustion space is in the head castings, the tops of the blocks being faced flat, the valve heads standing up a slight amount from the surface of the blocks.

All valves have ports 2⅛ in. in the clear and are tungsten steel head and stem, with 60-lb. springs. The diameter of 2⅛ in. is maintained on the exhaust ports right out to the manifold flange but the intake is restricted to 1 11/16 in. at the flanges, the desire being to maintain a fairly high velocity up to the moment of entering the cylinder. The cylinder walls are 5/16 in. thick. Water completely surrounds each cylinder and valve-seat. Each cylinder block is attached to the crankcase with seven ¾-in. studs, the base flange being ½ in. thick at the thinnest points and 1 in. thick at each holding-down stud boss. The water-inlet flanges, which are on the sides of the blocks remote from the manifolds, are 1 3/16 in. in diameter, and the outlets of the head castings are the same size.

The crankcase is all aluminum, including the bell housing and the oil-pan. The bearings are rigidly welded and the whole case is extremely stiff. At the rear end there are two deep arms which act as the rear supports.

Here the diameter of the case and of the flywheel housing is such that the arms are extremely short; they are formed in such a way that the top of the bell makes a complete arch construction from top to tip of the arms, so adding considerable to their natural strength. The front support is a spigot on the front-end cover turned and held in a swivel collar on a dropped cross member of the frame, so giving a three-point support with sufficient flexibility to counteract all stresses in the main frame.

Complete pressure lubrication is used even to the extent of feeding the wristpins by means of tubes secured to the connecting-rods. Oil is fed to the three main bearings, thence by straight holes diagonally to the crankpins and thence to the wristpins. The pump is in a well at the extreme rear right end of the crankcase oilpan, where it is separated from the rest of the system by a wall that prevents oil falling from the bearings from entering without first passing through the elaborate screening system. The forward part of the pan is very shallow so as to give great clearance over the front axle and slope toward the deep rear end, which contains all the oil. The top of this sump is closed by a sheet of thin steel having in the center a funnel reaching nearly to its bottom. This funnel is surrounded by a wall reaching nearly up to the sheet steel just mentioned so that oil has to pass down the funnel and then up again over the wall, the chamber into which the funnel discharges being thus always full; this is the settling chamber, designed to catch all particles of carbon and impurities and prevent them from passing on into the main oil reservoir. However, after passing over the wall beyond the funnel there is still a large screen of wire mesh to be passed, and another screen is used on the actual pump intake. The oil circulation is from pump to bearings to settling chamber to first screen to second screen, and then round again. The settling chamber can be cleaned by a plug in the bottom, and draining it does not affect the main body of the oil, so very little need be wasted.

The tappets are housed individually in the crankcase, each being a complete assembly of roller, hollow adjustable plug and guide. They are held in in pairs by dog clamps and studs. The timing is as follows: Exhaust opens 45 deg. early, closes 5 deg. late; intake opens 12 deg. late, closes 35 deg. late. There are three diameters for the camshaft bearings, 2¼, 2⅛ and 2 in.; their lengths being 2¼, 1¾ and 1⅜ respectively. On the rear end of the shaft there is a skew gear driving the oil-pump shaft, this being at the extreme end beyond the rear bearing. Thrust from the gears is carried to the front end of the shaft, and returned by a spring-backed hard steel plunger, which sets in a socket in the front-end cover. The pump shaft is, of course, vertical. The coupling to the pump itself consists of a short coil spring with the ends bent across the coil diametrically. Both the drive shaft and the pump shaft are slotted and the ends of the two nearly meet the bent over extremity of the springs setting in the slots. This allows the oil pan and the pump with it to be removed and replaced with a minimum of trouble in the front end.

There are four gears, the crankshaft pinion pressed on the end of the shaft, the camshaft wheel driving the generator gear, and on the other side the gear for water pump and magneto. The governor motion attaches directly to the front end of the camshaft. Thus, on the right-hand side of the engine the generator, the carbureter and both manifolds are placed, while on the left-hand side are the water pump, magneto and battery-ignition distributor, the latter being set on top of the front end case where it can be driven by skew gear from the water-pump drive-shaft. This makes for ease in linking together the magneto and the timer-advance controls and keeps all wiring on the one side of the engine.

The governor consists of steel balls held between a disk that can slide forward against a spring and a female cone fixed to the camshaft front end. In moving forward the disk bears upon the short end of a vertical lever, the upper end of which is linked to a throttle in the intake manifold just above the carbureter-attachment flange. This lever is fully inclosed and the spring which pushes against the centrifugal action of the balls is set in the case halfway up the lever. Here there is a threaded plunger with a lock nut by which the pressure on the spring is set; both pin and lock nut are secured when set by a sealed wire that entirely prevents unauthorized adjustment. The throttle, operated by the governor, is the usual butterfly sort, but is supported a little off center so that the suction of the engine tends to open it, this making for a quick reopening and preventing sluggish action.

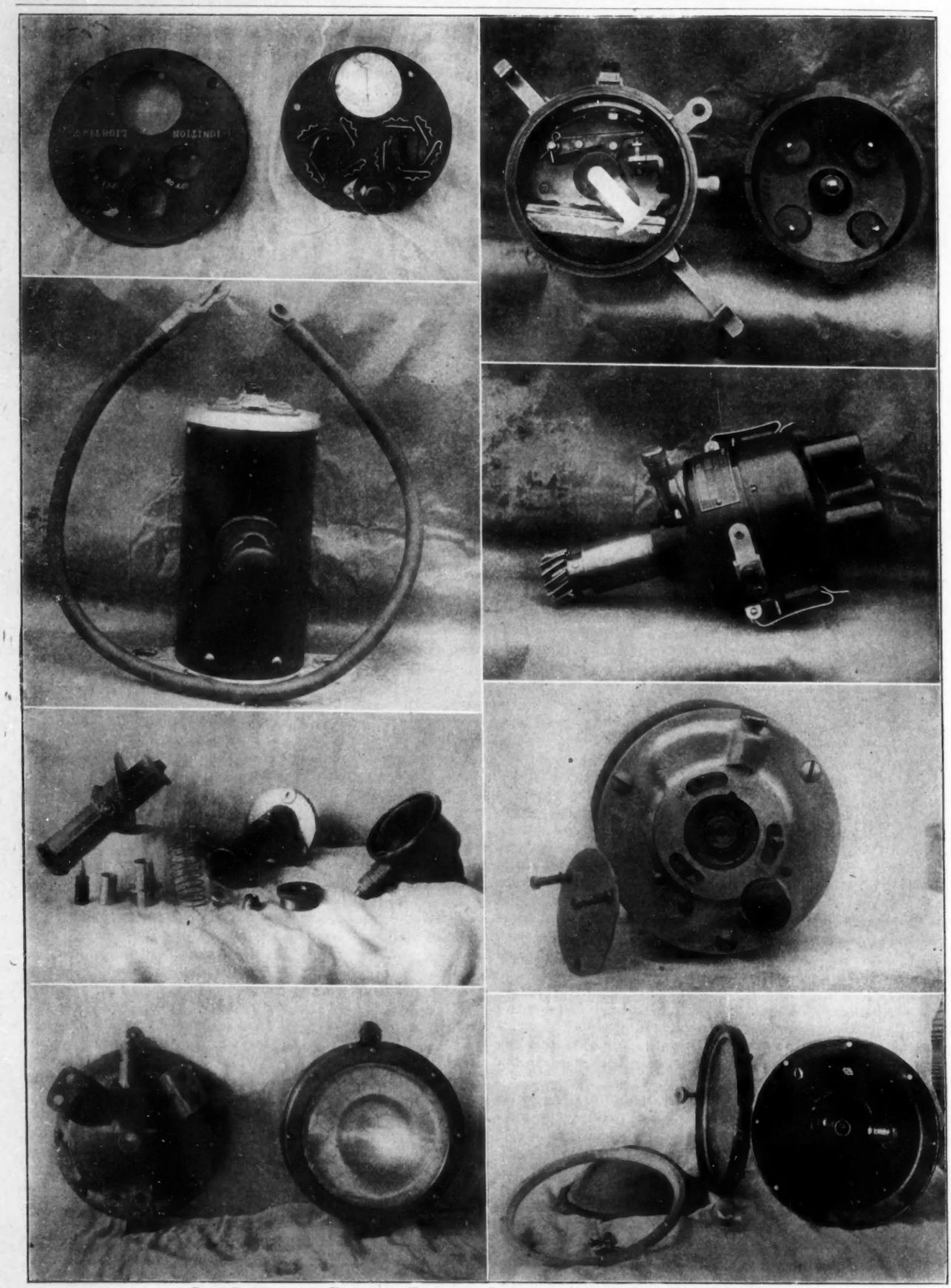
The water pump is a separate assembly and its shaft is coupled to the drive shaft, which is set in the crankcase and carries the gear. This makes the pump detachable without disturbing the front end. The magneto is set well back on the left-hand side and is coupled to the rear end of the pump-shaft.

The crankshaft is a conventional design; the diameter is 2½ in. on the three main bearings and 2⅜ on the pins. The bearing lengths are 4 in. for the rear and middle bearings and 3 1/16 in. for the front, the pins being 3 in. long. The webs are very stiff, the long one having a section 3¾ in. wide by 1¾ in. thick maximum, the 7 deg. draw angle subtracting little from the thickness at the edges. The proportions allow straight holes to be drilled for the oil direct from each main bearing center to the pin centers.

The flywheel is 20 in. diameter and 4 in. wide on the rim, the weight being 130 lb. The cast-iron pistons are fairly heavy, 6⅛ in. long, and with three rings and a 1⅜-in. hollow wristpin locked in position. The pin center is 2⅝ in. from the bottom of the piston. Ten thousandths of an inch clearance at the top and over the upper ring is called for and four thousandths on the lower ring and the rest of the skirt.

The manifold system is designed to take care of heavy gasoline and is regarded as the most experimental thing about the engine. The exhaust manifold is conventional except that at the center it has a rectangular opening. The intake ports are below the level of the exhaust ports so that the intake manifold flanges can be attached. The intake-manifold branches come out and up in an easy sweep. Where they join there is a rectangular face matching the one on the exhaust manifold and a sort of box like a muff on the intake. These two bolt together with a gasket between, thus allowing the exhaust to play upon the point where the two branches of the intake connect. The short vertical part contains the governor throttle and ends in the carbureter flange. The carbureter is set high and will, of course, be a vertical model; the type will be settled by trial.

The multiple dry-disk clutch contains eighteen plates and is completely enclosed in a bell-housing. It is detachable from the flywheel in practically the same way as a unit powerplant. The aluminum casting also embodies a platform to which the gear lever and hand-brake control unit is bolted. The leverage is such that the clutch has a reasonably heavy pedal action, and the throwout bearing is unusually large to give it great durability. Between the clutch and the transmission is a



SOME PARTS OF THE ELECTRICAL EQUIPMENT DESIGNED FOR CLASS B MILITARY MOTOR TRUCKS

short universal shaft having joints similar to those used for the main tubular propeller shaft.

The transmission gives four speeds with direct on high and the lowest gear ratio allowing for the 9.5 axle reduction is 56 to 1. Both shafts are in the same horizontal plane and run on ball bearings. The gears are wider than is usual. Provision is made for attaching a winding gear to the side of the transmission if required. The case is aluminum and clutch and transmission together weigh about 300 lb. The transmission is ingeniously hung. At the rear are two lugs drilled to receive pins on a transverse axis. These pins also pass through the ends of a pair of brackets hanging from a plain pressed-steel cross-member. The front end of the case has a "nose" surrounding the bearings of the main shaft; this nose is held up to a bracket hung from another cross-member by a cap like a bearing cap. The cap grips the case loosely so as to allow a floating fore-and-aft movement. This suspension makes it easy to remove the case since it is only necessary to remove the cap and knock out the two pins at the rear after disconnecting the pins in the three gear-shifter rods and disconnecting a universal-joint in front. The slip joint takes care of the universal on the propeller-shaft. The last mentioned is normally almost horizontal in a practically perfect position for the Hotchkiss drive.

The axle is a full-floating pattern with a pressed-steel case and has taper roller bearings throughout. Both sets of brakes are expanding, side by side on the same drums. These brakes are of the band type and are provided with adjustment for setting the concentricity of the bands. In laying out the brake connections great care has been taken to plot the path of the brake-lever eyes as the spring deflects. The cross-shafts, of which there are two, are placed so that axle movement will have a minimum effect upon the brakes to compensate for torsional deformation of the spring. The axle brake-levers are carried up until the eyes are nearly in line with the top plate of the spring; thus the spring deformation causes an up-and-down movement of the levers instead of a horizontal one, and the vertical movement does not affect the tension of the brake rods.

DESIGN OF CLASS A MILITARY TRUCKS

NOW that the design of the heavy-duty war truck has been completed, the Quartermaster Department will proceed at once with the preparation of drawings for the Class A model. This will be virtually equivalent to a 3-ton commercial truck, although its pay-load will be specified as 3000 lb.

A complete organization has been built up to design the Class A truck. This work will be conducted by the Engineering Division of the Quartermaster Department. Its composition and functions will be of interest to the members of the Society. In order to understand how the engineering work is being handled, it will be well to review the Q. M. C. transportation activities in general. At the head of it all, of course, is Quartermaster General Henry G. Sharpe. Under him, as chief of transportation, is Brig. Gen. Chauncey B. Baker, with Col. C. B. Drake as his assistant. There are a number of forms of transportation in the Quartermaster Department, but the motor transport activities are directly in charge of Major James A. Furlow. The officers previously mentioned have their American headquarters at the State, War and Navy Building, in Washington.

Cooperating with Major Furlow are two civilian organizations; the Motor Truck Committee of the War Industries Board, advising as regards broad industrial problems, and the Society of Automotive Engineers, acting through various channels of its organization as an advisor on questions relating to truck design. Both these organizations have Washington offices at the Munsey Building.

Under Major Furlow is the Engineering Division with Major Edward Orton, Jr., in direct charge. There may be said to be four general activities of the Engineering Division: Experimental and Designing Branch, Production Branch, Production Engineer, and Correspondence and Records Branch.

The officer in charge of the Experimental and Designing Branch is Capt. Wm. M. Britton. Under him are technical experts on such subjects as testing; engines; chassis; transmissions, axles and wheels; bodies; electrical equipment; rubber and accessory equipment. These men render advice on their specialties as needed in settling the detail problems that are being met with in producing the war trucks.

Under Captain Britton also will be the force of engineers who will design the Class A war truck. The supervisory phases of this work will be handled by a committee on design, consisting of Captain Britton, B. B. Bachman and A. J. Scaife. Working under this committee will be groups detailed to submit designs for the principal parts of the truck.

The personnel of these groups, as far as it has been designated, follows:

Engines—W. A. Frederick, A. F. Milbrath and J. B. Fisher.
Axles—A. W. Russel, R. E. Fries and G. W. Carlson.
Transmission, Clutch and Control—A. W. Copland, W. C. Lipe and S. O. White.
Steering Gear—W. N. Osborn, S. O. White and D. E. Ross.
Universal Joints—C. W. Spicer and B. H. Urschel.
Electrical—Lieutenant Matlack and F. C. Kroeger.
Wheels—R. J. Burrows, Mr. Still and R. H. West.

These groups will work in much the same way as did the groups that prepared the designs for the Class B truck, but the experience previously gained will undoubtedly prove of great value. A schedule will be laid out for all the various steps, and it is predicted that the records made in designing the Class B truck and in producing the first samples will be broken and to a considerable extent.

Mr. Girl's work as Director of Production of Military Trucks was outlined in the September JOURNAL. His duties are to supervise the production of standardized military trucks with the assistance of Messrs. Quinlan, Morgan, Tracy, Bourquin, Utz and Drefs, these being in charge of raw materials, plants, parts, assembly, inspection, charts and statistics respectively.

Mr. Girl and his staff are housed at 1421 Eye Street, N. W., Washington, while the remainder of the Engineering Division under Major Orton is quartered at the Union Station in Washington.

E. G. Gunn has been appointed as Production Engineer. His duties will be to pass on specifications and in general to correlate engineering and production requirements. Under Mr. Gunn will work a chief of specifications with the necessary index and file clerks, and a chief draftsman with checkers, layout men, detailers, tracers and blueprinters.

More than three thousand different drawings were required for the Class B truck. An immense amount of correspondence regarding the different parts of the trucks is continually being handled by the Engineering Division. The Correspondence and Records Branch will look after all this detail under a chief clerk, with assistants and stenographers.

SYMBOL STANDARDIZATION SUGGESTED

The Society for the Promotion of Engineering Education, which is composed of a large number of professors and instructors in engineering schools, together with engineers and others interested in the work of the organization, has been working for some time on the standardization of technical terms. Its Committee on Technical Nomenclature has prepared an extensive list of technical terms, together with the abbreviations that should be used for such terms. The latest activity of this committee, however, is the formulation of symbols for mechanics and hydraulics. It is believed that some standard symbols should be adopted, and in order to determine the best practice, the committee asked for suggestions from a number of men engaged in teaching mechanics and hydraulics. From the suggestions made by these men, a list was prepared and sent to other professors, editors and engineers. The accompanying list, which has been approved by the Committee, is said to represent the consensus of opinion of all the experts consulted.

In commenting on the symbols proposed, Professor John T. Faig of the University of Cincinnati, who is chairman of the S. P. E. E. Committee on Technical Nomenclature, states that the list is presented in the hope that it will assist in the evolution of a standard list. The Committee on Technical Nomenclature of the Society for the Promotion of Engineering Education consists of John T. Faig, Charles Warren Hunt, F. L. Raymond, W. T. Ennis and S. E. Earle. While the list is very short, it would seem that the Committee has made an admirable start, and that engineers generally should adopt the symbols given in its list.

Any suggestions from the members as to changes or improvements in the symbols given, should be sent to the publication manager of the Society at the New York office, who, having already been asked to criticize the list, suggested changes which were incorporated in the accompanying list. It is understood that this list is issued at present in order to obtain construction criticisms.

Acceleration, Angular	α	Inertia, Polar Moment of	J
Acceleration due to Gravity	g	Inertia, Rectangular Moment of	I
Acceleration, Linear	a	Length	L
Area	A	Load, Eccentricity of Application of	e
Breadth	b	Mass	m
Center of Rotation	O	Modulus of Section	Z
Coefficient of Friction	f	Modulus of Elasticity, Young's	E
Coefficients and Constants	C, K	Moment of Force	M
Deflection of Beam	Y	Moment of Inertia, Polar	J
Depth	d	Moment of Inertia, Rectangular	I
Diameter	D	Quantity of Liquid Flowing	Q
Distance passed over	s	Radius	r
Distance of Extreme Fiber from Neutral Axis	c	Radius of Gyration	k
Eccentricity of Application of Load	e	Reactions	R
Efficiency (Hydrau., Mech., Vol.)	e_h e_m e_v	Revolutions per Unit of Time	N
Force	F	Stress, Unit	S
Force, Moment of	M	Time	t
Friction, Coefficient of	f	Torque	T
Head	H	Velocity, Angular	w
Height	h	Velocity, Linear	v
Horsepower	H_p	Volume	V
Hydraulic Radius	R_h	Weight	W
		Young's Modulus of Elasticity	E

GROUP OF NATIONAL ARMY MEN BEING INSTRUCTED IN MOTORCYCLE OPERATION

The Motorcycle in Army Use

MOTORCYCLES both with and without side-car attachments are now being used very extensively by the various branches of the United States army. The highly specialized nature of this equipment calls for equally specialized methods of maintaining the same. Without the adoption of such methods it will not be possible to obtain the greatest efficiency from the use of motorcycles.

The recommendations following are the result of carefully following up results obtained in using motorcycles on the Mexican Border during the past eighteen months.

The motorcycle requires a driver who has had experience and training in order that satisfactory results may be obtained. It may be safely stated, and this statement is borne out by the experience of the officers in charge of provisional motorcycle companies on the border, that the relative division of efficiency is 90 per cent for the operator and 10 per cent for the equipment. Such a division makes it quite evident that some provision must be made for training satisfactory operators.

The motorcycle is not in any sense a vehicle like the bicycle; that can be handled satisfactorily without centralized control. Attention has been brought to many instances where motorcycles have been issued individually for use at various army camps and have not given satisfaction. The equipment has been turned over to a private who had no knowledge of the proper care or attention that it should receive. From "joy riding" and other abusive practices it has been rendered practically useless within the first 1,000 miles of service. So many of these cases are brought to the attention of the service department that the following recommendations should be given consideration:

(1) The establishment of centralized control over all motorcycle units in use by our army. By this it is intended that all motorcycles shall be formed into individual company units commanded by an officer familiar with the equipment.

(2) The establishment of a training camp in this country, the same to be maintained by the Government with the joint cooperation of the motorcycle manufacturers for the purpose of training officers and men for this service.

(3) The establishment of a base shop overseas, completely equipped to handle motorcycle repairs only. It is very important that this branch should be absolutely divorced from the automobiles, motor trucks or airplane shops. This does not necessarily mean that such shops should not be housed under the same roof, but the motorcycle organization should be an individual unit in itself in the hands of experienced motorcycle men.

(4) The establishment of divisional field shops which shall to all intents and purposes be branches of the base shop.

CENTRALIZED CONTROL OF UNITS

A centralized and capable control must be established to get the best efficiency from motorcycle equipment.

*From recommendations forwarded to Committee on Organization. War College Division, General Staff. Washington, D. C., by a committee on organization of the Motorcycle Division composed of Captain F. C. Hecox, Frank Schwinn, F. C. Butler, Jr., Wm. S Harley and A. W. Herrington.

If the motorcycles are divided into companies in charge of a competent officer, one company can then be made up entirely of the same make of motorcycles. This practice is most desirable when the question of supplies and spare parts is taken into consideration. It would avoid duplication by eliminating the necessity of carrying two complete part stocks for each company. Parts available for the care and repair of the machines would be centralized under capable control and therefore readily available in time of need.

When handled in company units, the motorcycle equipment would be in charge of responsible officers familiar with the amount of attention and service that the equipment requires.

Under this method also the personnel of the company is under immediate observation of the commanding officer. He becomes intimately familiar with each man's individual qualifications and fitness for any special detached service. Proficiency in any one branch of the service evidenced by any man may be used to the greatest advantage. These men may receive specialized training in scouting, map work or signaling, and their particular training might grade them as experts in any one of these individual items.

During the recent experiments on the Border there were formed two provisional motorcycle companies, one with the 4th Infantry at Brownsville, Tex., and the other with the 61st Infantry at Fort Bliss, El Paso, Tex. The motorcycles in each case were practically in charge of capable officers responsible for their care and maintenance. In addition to these companies there were a number of points where the motorcycles were used individually and were in charge of privates. In practically every instance where the centralized control was lacking results were noticeable by their absence.

Centralized control and the handling of motorcycle equipment in company units were adopted by the British Army at the outset of the present war, and has since been continued by it as being the only efficient method of handling such equipment.

Training Camps in United States

This recommendation is made in view of the extreme difficulty of obtaining satisfactory operators for motorcycle equipment. The camp should be maintained in this country by the army to train them for this particular service. Expert instructors should be supplied from the organizations of the various motorcycle factories. The camp, of course, would be in charge of regular army officers. It would be formed with three distinct purposes in mind:

To train efficient officers to command motorcycle companies.

To make motorcycle riders out of enlisted men who show a natural aptitude for the work.

To take motorcycle riders who have previously been enlisted and trained as soldiers and give them further instructions in handling the motorcycle under army regulations.

With reference to the third point it is intended that this camp should not be hampered with the details of training enlisted motorcycle riders in the school of the soldier. Any motorcycle riders enlisted or drafted should be required to qualify in this work in the regular cantonments given over to such training and they could be later detailed to the motorcycle training camp for final instructions before entering service.

This camp should preferably be placed in charge of officers who have already had definite experience with motorcycle equipment. The service of these officers combined with the assistance of the experts that the motorcycle factories would be in a position to supply would make it possible to organize a camp of such size that 10,000 men with the necessary officers could be trained for service in a period of thirty weeks from the time the camp went into operation.

A certain proportion of machine-gun companies in each army division should be made complete tactical motorcycle equipped units. In addition to this tactical company there should be one headquarters company attached to each brigade headquarters. This would obviate the necessity of requisitioning the equipment used in the tactical companies for transportation purposes at headquarters. Like the tactical company, this headquarters company should also be a self-contained and self-supporting unit.

This headquarters company should be organized upon practically the same basis as the machine gun company, with the exception of the fact that 27 motorcycles with side cars and two 1½-ton motor trucks mounted upon pneumatic tires would take care of all necessary requirements.

These companies could be turned out from the training camp in complete units ready to receive their equipment and proceed overseas for service.

Base and Division Shops

These shops for handling motorcycles should be kept entirely distinct and separate from those required to maintain any other motor-driven transport equipment sent to the front. Automobile and motor-truck mechanicians are not in any way qualified to handle motorcycle service, nor can they do so successfully without individual specialized training in this work. Experience has proven that when they are so trained it is seldom that they turn out as good a grade of work as would be obtained from a man who has specialized upon motorcycles only. Proper experience demonstrated that where both motorcycles and automobiles are handled by the same mechanics one equipment is invariably slighted in favor of the other. Mechanics with training sufficient for this work can be obtained from the motorcycle factories, and the work in handling motorcycle service should be detailed to such men. They should be preferably enlisted upon recommendation from the various manufacturers.

The motorcycle manufacturers are interested in doing everything within their power to see that the desired service is obtained from motorcycle equipment. In view of the large number of these units that have already been purchased by our army urgent action upon these recommendations is necessary in order that such results may be obtained.

It is known that the English motorcycle riders have done splendid service, and a fitting tribute was paid to them by Field Marshal Sir John French in his despatch of Nov. 20, 1914:

"Carrying despatches and messages at all hours of the day and night, in every kind of weather, and often traversing bad roads blocked with transports, they have been conspicuously successful in maintaining an extraordinary degree of efficiency in the service of communications.

"Many casualties have occurred in their ranks, but no amount of difficulty or danger has ever checked the energy and ardor which has distinguished their corps throughout the operations."

Automotive Engineering in the War

By PRESIDENT GEORGE W. DUNHAM

IN the last analysis war as fought to-day is substantially the matching of great engineering enterprises, and in the long run the side with the best engineering genius (including in that term productive and organizing ability) will win the contest. The ramifications of engineering accomplishments are infinite. They include the automotive, mechanical, civil, mining, electrical, chemical, sanitary, marine and railway fields, not to mention others of scarcely less importance. To attempt to say which is of greatest value is to work an injustice to all, for all are interrelated and interdependent. However, it is quite evident that the automotive field is second to none, as will be found on analyzing the situation.

The term Automotive includes the motor car, aeronautic, tractor, motorcycle, marine and stationary engine fields—in fact, every type of self-propelled vehicle. The design, production, operation and upkeep of such apparatus are of the utmost importance in time of peace. During a period of war these problems multiply many times because of their magnitude and the pressing importance of speed in their solution.

Thus it is that the Automotive Engineer must enter the Government service, as many have already done, or otherwise discharge his patriotic duties by the closest cooperation with those in authority. For this reason the Society of Automotive Engineers has established in Washington for the period of the war an office, the prime function of which is to place at the disposal of the Government the remarkable resources of the Society and of its members.

In considering the situation it at once becomes evident that this is not only a war of engineering competition, but that the internal combustion engine is one of the most vital elements in every phase of its conduct, a condition which will explain the reason for the extraordinary activities of the S. A. E., which will now be outlined.

Transporting Men and Munitions

Where the railroad ends, as well as in many cases where it is inadequate to handle the necessary volume of traffic, the motor truck must assume the tremendous burden of transporting men and munitions. The organization of motor-transport service is indeed a problem worthy of the best engineering talent and one in which the Automotive Engineer has done splendid work. Without the motor transport the French could not have defended Verdun, for the rail facilities were entirely inadequate to handle the great quantities of shell and other munitions required. Hence the automotive engineer deserves a fair share of credit for the splendid victory there won by the French. On other fronts much the same results have been accomplished.

The problems to be met in keeping a fleet of army trucks in operation are far more serious than those encountered in normal peace service. The road conditions are frequently wretched, the loads too are apt to be heavy, a combination which results in unusual stresses and shocks with consequent breakage or rapid wear. As a result the necessity of repair and the supplying of spare parts for renewal become acute. It has been stated on good authority that frequently two-thirds of the trucks on the Western Front are out of commission, awaiting or undergoing repairs. Conditions of this character arise in part through lack of standardization. Multiplicity of types is an evil from which the Allied Armies have suffered in no small degree. The number of parts to be supplied is so great that the liability of trucks being laid up for lack of necessary parts is correspondingly serious. In spite of these facts the Allied Governments have not yet standardized on a single design.

Standardized Truck Design

Thus it has been left to American engineers to solve the problem, and it has been done in characteristic American fashion, and almost wholly, I am proud to say, by members of the Society of Automotive Engineers. It is fair to say that this result could hardly have been attained without preparation and years of experience along similar lines within this organization. The work, in fact, was initiated by the Society and great strides toward its completion accomplished before it was taken over and consummated under Government auspices. But even when this was done, the same group of Automotive Engineers who had started the work were retained by the Government to prepare the finished design.

As a result the Government has in process of production a truck which is not only rugged and finished as a design, but is capable of rapid production, and above all simple and easy to repair—the parts being made with a view to easy renewal and absolute interchangeability. There is also a smaller number of parts, and in many cases the same parts have been used in both of the two sizes thus far designed. Therefore, it will be necessary to to carry a stock of repair parts much less than would be required if they were of different designs. The result is that the service problem is greatly simplified. This in turn will have a favorable effect upon the supply of parts from a duplicate source. In consequence it is expected that a much larger part of the trucks in use will be kept in active operation than would otherwise be possible.

For many years past the Society has been carrying forward an extensive program of standardization. It need hardly be said that in every possible case the standards created by the Society have been made use of in the design of the war truck. What is quite as important is the fact that an organization accustomed to conducting standardization work was in existence, was working smoothly, and successfully met all demands when put to the extreme test. The assistance of this organization was enlisted by the Government, some fifty engineers, practically all of whom were S. A. E. members, having been employed by the Government to complete the design of the truck.

The work of the Society has not however by any means ended with the completion of the design. The production

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of the trucks, the inspection and ultimately their operation, will of course be under the direction of the Quartermaster Corps. The organization within the Quartermaster Department, however, which will handle these matters, is made up largely of Automotive Engineers, practically all of whom are members of the Society who have entered the service through recommendations made by officers of and others in the Society.

The production will be accomplished through the automobile industry under the supervision of Automotive Engineers. The inspection of the trucks will then be carried out by a special corps of men enlisted in the Quartermaster Department for this purpose. At the same time an extensive motor repair base is being organized over seas where other engineers will be called upon to place and keep in operation trucks shipped from this country. Again the work will be undertaken by Automotive Engineers, many of whom have already been commissioned for this service.

While the work of motor transportation is carried forward largely through the Quartermaster Corps, several other branches of the service need motor-driven vehicles of various descriptions. The Engineer Corps, for example, will use a large number of trucks for the handling of material. In all probability these trucks will be identical as far as the chassis is concerned with those now being provided through the Quartermaster Corps. In the Ordnance Department, the Signal Corps, the Medical Corps, and in other branches of the service special motor-propelled equipment is being provided.

The Signal Corps will require relatively light high-speed trucks to act as airplane tenders. These trucks will be mounted on pneumatic tires and be capable of speed of about 50 miles per hour. In the Medical Corps a somewhat similar chassis is to be used for ambulances. These machines, like those in the Signal Corps, are to be capable of operation over very rough grounds, in many cases where no roads whatever have been built. Again the design, inspection, production and operation of these vehicles are undertaken by Automotive Engineers with special qualifications for such work. The men in charge of the engineering phases of this work are almost without exception S. A. E. members.

Motorization of Field Artillery

In the Ordnance Department a quite different set of conditions must be faced. The increasing scarcity of horses, the necessity for greater speed and greater tractive effort, have made it necessary for the Ordnance Department to undertake extensive motorization of its equipment. Accordingly, another group of Automotive Engineers, men for the most part with experience in the design of tractors, are now working on this problem. Heavy ordnance which heretofore it would have been impossible to move successfully without motor-propelled equipment, is now moved over ground almost impassable without this modern motive power. Here again the service of the Automotive Engineer has been enlisted and the Government is being provided with equipment which in many cases will completely replace animal power heretofore supplied. As in other cases, the development, production, inspection and operation of this apparatus will be in the hands of the Automotive Engineers.

In addition to the tractors used by the Ordnance Department, a large number of four-wheel-drive trucks will be provided for the handling of ammunition and other similar purposes. These vehicles, a comparatively modern development, can operate over rough ground under conditions where the ordinary type of road vehicle would find it difficult to secure the necessary foothold.

Among the other types of motor-propelled apparatus used in war work, the Automotive Engineer has developed a new and exceedingly useful engine of war popularly known as the "tank." The accomplishments made possible by the use of this novel type of automotive apparatus form one of the most interesting chapters of the history of the Great War. So far as I am aware, no announcements have been made by the Government concerning its plans for the development of this type of machine. It is by no means to be doubted, however, that when the troops of this country are ready for service, they will be provided with equipment of this character second to none in use by the Allies. It is betraying no confidence to state that the Ordnance Department is working upon developments of this character, and it may be noted with just pride that again the work is in the hands of competent Automotive Engineers, among whom are representative members of the Society.

At the other end of the extreme in types of self-propelled vehicles is a smaller and lighter, and by no means the least useful of machines designed by Automotive Engineers—the motorcycle—which is used extensively for despatch work and for transporting machine guns and their operators.

Much that has been said regarding other motor apparatus applies also to these two and three-wheel vehicles. Here again the Society has rendered effective assistance to the Government in standardization of parts, for, as in other cases, the Secretary of War delegated officers in the Quartermaster Corps to confer with committees of the Society on the problems relating to development, standardization and use. The work of the Society's committee in this regard compares favorably with that of other committees and individual members already mentioned.

Thus far I have dealt most particularly with types of self-propelled vehicles which operate on land. The field of the Automotive Engineer is by no means confined to the development of machines of this character, but includes machines which fly through the air and others which are propelled on the surface of water.

Purpose of Liberty Engine

The use of aircraft in military operations is now understood to be a most important factor in the winning of the World War. The program of the U. S. Government has been given extensive publicity, but it is perhaps not fully known how important a part in this program Automotive Engineers have already played and are bound to play in the future. The development of the Liberty Engine is properly credited to engineers who are members of the Society of Automotive Engineers. Their work has, like that on the War Trucks, been greatly facilitated by the present and past activities of the Society. Due credit must be given the Allied Governments for data furnished to our engineers who designed the Liberty Engine, but it should not be forgotten that this engine is strictly an American product, having been designed with a view to rapid production, standardization and interchangeability of parts, factors which are not present to the same extent in other designs. The benefit which this will have in increasing the effectiveness of our fighting contingents at the front can scarcely be overestimated. The Aviation Engine is, of course, a very high-strung machine, one which must develop great power with minimum weight. For this

reason and because of the fact that the engine operates under full load and at high temperatures practically all the time it is running, its depreciation is relatively rapid. This in turn makes the service problem much more difficult, so that new parts must be frequently supplied in order to keep the maximum number of machines in operation. Here, again, we realize the importance of standardization, and the necessity for absolute interchangeability, factors long appreciated by the Automotive Engineers and practiced especially in the automobile industry in this country. The production, inspection and upkeep of aeronautic engines, as well as the planes in which they are mounted, are similar problems in which Automotive Engineers are now doing yeoman service. There is no more important work that they can do. The Society is justly proud of the work which its members have accomplished in this direction.

More such men are constantly being required in the work of the Signal Corps. The possibility for development in the aeronautic field, both during as well as after the War, is almost unlimited. Strenuous efforts now being put forward by engineers engaged in this line of work are extremely potent factors in helping to win the War. Aside from the important activities of air forces immediately at the front, there is great opportunity for bombing squadrons to do most effective work against the German lines of communication, as well as against their great munition plants. If some twenty airplanes can do such great damage as we know they have caused about London, what is to be expected of the 20,000 machines now in progress of perfection in this country.

But it is quite apparent that the activities of an airfleet are not to be confined to operation over land. The development of seaplanes is now rapidly progressing, and the activities of this type of aircraft are expected to have an important bearing upon the outcome of the War. The flying-boat is no longer a matter for speculation; it has proved possible to build a machine which will have the seaworthy qualities of a small yacht, and that at the same time can take the air on occasion in the locating and destruction of the submarine. The solution of the submarine problem may come through the adoption of one of the large designs of this character. It is a line of endeavor in which every engineer with the proper qualification should strive.

The seaplane is not, however, the only type of craft for marine use in attacking the submarine which has been developed by the Automotive Engineers. The so-called submarine chaser, for the development of which great credit is due, is another of the war products of the Automotive Engineer. Several hundreds of these craft have been used for months on the British Coast with the result that the submarines seldom attempt navigation less than 100 miles off shore. The rapid production in large numbers of standardized craft of this kind is another of the intensely interesting chapters in the history of the War. The design and construction of engines used in a goodly proportion of this type of craft constitute another of the problems which Automotive Engineers have handled with marked success.

Use of Stationary Units

There is another branch of Automotive Engineering about which much less has been written, but in which work of great importance is being done—the development of small stationary or semi-portable units for the operation of wireless sets, searchlights, pumps, isolated electric lighting plants and machinery in portable repair shops. These perform important functions in the great military machinery of modern times. The Automotive Engineers responsible for their design and operation deserve equal credit with those who have contributed to the more spectacular details of modern warfare.

It should not be concluded from the foregoing that the function of the Automotive Engineers is limited to those engineering matters having to do with apparatus used directly at the front, or contributing immediately thereto, for many of the types of apparatus are as useful in our industrial activities as in what may be termed direct military operations. The use, for example, of trucks in handling the materials in our great munition plants is comparatively commonplace, but so important that many industries would be crippled if for any reason it should become necessary to withdraw these from the performance of their every-day tasks. Much the same may be said also of the passenger car, which has become such an important part of our modern life. The Automotive Engineer who stays at home and attends to the production of any type of self-propelled vehicle is therefore performing quite as patriotic a duty as those who undertake engineering work at the front.

Development of Farm Tractors

There is a branch of Automotive-engineering activity referred to previously in another connection, in which work is being accomplished just as important as that having to do with any direct military activities, namely, the development and production of the farm tractor. This type of agricultural machinery is playing a tremendous part in the production of food, which after all may be the determining factor in winning the War. The average modern farm tractor is not only capable of doing the work of several horses, but in many cases can do this under conditions in which animal power cannot be applied efficiently. The horse itself consumes a considerable part of the product from the acreage it is used to cultivate. Not so with the tractor. I shall not attempt to say how great an increase in the production of material can be affected by the increased usage of power machinery, but it is recognized by all who have investigated the subject that the total production of food in this country can be increased enormously by the application of the farm tractor in many forms, small as well as large.

It would be a hopeless task to try to indicate all the ways in which Automotive Engineers are performing valuable service in the prosecution of the War. In any branch of the service, whether here or with our men in France, wherever automotive apparatus is made or used, there will be found the Automotive Engineer striving to do his part and always willing and anxious to help the other fellows to cooperate, and looking for more work to do.

In conclusion, a word to the members of the Society of Automotive Engineers present. I consider it one of the greatest honors attainable to be a member of the Society, to be one of these remarkable men who have accomplished so much; to be associated with these men who conceived the idea of standardization in its broader sense, who have set an example to the world in cooperative endeavor, and who, though of a great diversity of interests, almost to a man stand as one for the practical standardization of all automotive apparatus and the broadening out and advancement of the industry.

Any work of this sort can only go a certain distance with a given amount of support. We have accomplished much, but we have hardly scratched the surface. I

want to urge that in the future the efforts of the members be redoubled in the furtherance of Automotive Engineering, that they be more generous with their time in the preparing of good papers, that local campaigns be instituted to obtain new members, and that they be conducted with such thoroughness and vigor that in a short time all eligible men will become members.

Consider the value of the things we have done in the past, the necessity of accomplishment at present and the possibilities of the future. Then, members of the S. A. E., organize and obtain as members every eligible man. The activities of the Society of Automotive Engineers have conclusively proved that anything good for the industry is good for the individual. So every bit one does to help in this membership work will react just so much to his own advantage.

Metallurgy in the Automotive Industry

By Ralph H. Sherry* *(Non-Member)* Detroit Section Paper

THE work of the metallurgist in the automotive industry is closely connected with the main branches of manufacturing—engineering, experimental, purchasing, and factory management. His own peculiar field, of course, comprises the specifying, inspecting and testing of material, and scientific control of the treatment of the materials. Of the chemist is required analytical control of the materials entering into the output and also of those upon which the factory is dependent for production. These functions have been well covered by articles in scientific and trade journals. The connection of the laboratory with production has not been so thoroughly covered and it will be the purpose of this paper to outline this phase of metallurgical work. In doing this it is possible to touch only upon the main points. Instances of faulty conditions will be mentioned, not necessarily because of their constant occurrence, but because of the serious delays which they may cause to production.

Selection of Designs

The first step in the manufacture of automobiles is the selection of designs for the parts. Here the designer is limited by the selling price of the machine and by the ability of the shop to manufacture the part under circumscribed conditions. This frequently leads to selection of certain standard designs on account of their simplicity in machining. One design of this kind is the square end milled at the end of a round shaft, a design belonging to the earliest days of manufacture and still used in certain parts. It should be obvious that through this operation the part is weakened and that the material over and above that of the size of square end is simply wasted. Upsetting the end of the shaft before milling, thereby gaining more stock for the operation but not at the expense of the shaft itself, will give more satisfactory results. This operation necessarily leaves sharp corners at these points, and, especially when case-hardened, gradual fracture may occur under alternating stress. Many cases of this kind have been observed and have frequently been thought due to the material until it was found that even with change of material there was no improvement. Some of the reasons for this will be discussed later. In some designs this square end will give perfect satisfaction until the weight of the machine is increased and then breakage occurs. The only remedy is to make some change in the design, as, for instance, the substitution of splines for the square ends.

Certain other designs are peculiar to the individual machine, brought out perhaps under production-stress. In time trouble with the part occurs either in manufacture or in service. In many cases of this kind a radical change in design is required and where trouble is persistent it will always be well to consider this point.

One of the fundamental principles of design is the avoidance of nicks and sharp corners in parts under alternating stress, yet there are few who are guiltless under this head. Cases in point may be readily found even at this late day. If there be doubt on this point, a test can be made with a bar about half an inch wide and one-quarter of an inch thick, of any steel of about 0.20 per cent carbon. Bend it back and forth in a vise and note the number of bends required for fracture. Take a similar bar three-eighths of an inch thick, nick with a V to one-quarter inch and bend. In nearly all cases fracture will occur on slight bending. Even scratches may have a marked effect. Heavy rear-axle drive shafts of the semi-floating type have been known to break on account of tool marks. Of course, if the axle is full-floating and under no alternating stress, rough tool marks are usually harmless. Grinding the first type of shafts has generally been found to stop the trouble instantly.

Parts may be designed properly with no nicks or sharp corners only to give way in service through some fault in manufacturing. In one case the machining operations on a pivot axle were changed to permit easier machining, and an apparently simple and proper method selected. After cutting the radius at the head, the spindle was machined from the smaller end toward the larger. The surfaces produced did not coincide, the result being that a small nick was left. These parts broke after very short service. Eradication of this nick stopped the trouble.

The effect of nicks has been determined in the alternating-stress test and it has been found that shafts which have been ground smooth will run under a considerably greater load without fracture than will shafts with tool marks. In the latter case the critical load will be found decidedly low. If the rough shaft is stressed below the critical load, its life will be indefinite. A slight increase in the load to just beyond the critical stress, will result in rapid deterioration.

Another bad form of design is the location of drilled or punched holes near the edges of parts under alternating stress, as, for instance, in frames and braces.

These are some of the most prominent points of design in its effect upon wearing quality. Another phase of design which deserves mention is the necessity for its

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coordination with the shop methods, a necessity which is greatest in the case of parts that require hardening. Frequently parts requiring partial hardening in a way that is practically impossible are handed to the hardening room. At times this trouble results from the use of a bad design and the remedy is put up to the hardener instead of to the designer.

In some cases the design is made to lower the cost of machining or assembly. An illustration of this was once noted in the design of a bolt about a half inch in diameter. One end was drilled leaving a wall a little over a sixteenth of an inch thick. A thread was cut in the outer wall of the drilled end and carburizing deep enough to permit grinding was called for. This meant carburizing practically all the way through and the result can be left to the imagination.

For case-hardened work especially, sharp ends and corners and other designs which permit the penetration from two sides to meet must be avoided. The piston-pin is a simple part requiring careful design and treatment. If it contains sharp corners, chipping off may occur after hardening, and a small radius should be used at such points. If drilled before carburizing the end should be kept as flat as possible or the whole end may spall off in a ring. If the pin hole is too near the end, complete hardening may occur in the section between the hole and the end of the pin. Drilling after the carburizing operation and before hardening is the simplest method of avoiding this trouble.

Partial Case-Hardened Sections

Partial hardening of many case-hardened sections will permit the use of many designs which are otherwise out of the question. Copper plating is a simple method and will give good results if handled with care, the principal factor of success being the removal of surface scale, dirt and grease. Bevel ring-gears should in most cases be copper plated before the finishing cut is made on the teeth. In the soft condition of the metal obtained by this method the gear may be subjected to a straightening process which would be impossible if it were surface-hardened all over.

When machining operations are required after hardening copper plating is largely used, but in some cases better and more economical results will be obtained by machining off the carburized layer before hardening. Shop conditions will generally determine the method to be selected.

Some of these considerations may appear ridiculous, but they are all drawn from life. They may serve to show that metallurgical considerations should enter into design, particularly in peculiar construction or where differential hardening is required.

Selection of Materials

After the choice of design the next step is the selection of materials. The materials used in automobile construction have been thoroughly examined and the results of testing them have been published so that this phase will not be extensively covered here. Steel is the material of widest range and greatest use and so must be considered here to the greatest degree.

The use of screw stock on account of its machining qualities is well known, the uses of the various grades of carbon steel need not be explained to the manufacturer, and it is well understood that the function of the alloy steels is to furnish greater strength, thus permitting lighter construction or greater hardness.

The selection of steel for purposes of construction requires a knowledge of the physical properties and of the various conditions inherent or resulting from treatment which may leave the material in good or bad condition. The factors which govern the choice of material are suitability and cost. It is a waste of material to use a high-priced alloy steel when a cheaper steel would serve, and it is equally a waste to try to economize on parts for which the best material is required. The choice of material may frequently be determined by test, but very often testing cannot approximate all the conditions of service, and the actual trial of the material in service is necessary.

Screw stock is frequently brought into question on account of the sulphur content, although it has given excellent service in some respects for years. In the earlier days it might be said that nearly all automobiles were built of screw stock. Transmission gears of case-hardened screw stock gave long and good service. The earlier chemists were obliged to find something upon which to hang faults and sulphur proved to be a convenient hook. These statements are not made to suggest the use of screw stock in unlimited quantity nor do they refer to all material thus designated. The effect of sulphur is the point under consideration, and there are many other conditions to be considered before this material is selected for use. Much of the commercial variety, especially Bessemer stock, is seamy, full of slag, or contains too much phosphorus, conditions which hardly make for suitable material for automotive construction. There are certain types of steel naturally seamy requiring a low sulphur content. At present alloy steels high in sulphur are entering the market because of a demand for more easily machineable material. One would not be far from wrong in stating that the mills cannot roll steel high enough in sulphur to be seriously harmful in most cases.

Many of the theories which were developed in past years are of the result of lack of knowledge combined with the very natural desire inherent in human nature to offer an explanation for all phenomena. The theory that metals crystallize under vibration is of this nature. The occurrence of coarse grains in fractured untreated steels led to this belief which at one time was quite general and which still persists in many places. Properly treated steels of fine grain seldom failed while the coarse-grained fracture of untreated steels was of quite common occurrence. This idea has probably done more to discourage investigation and improvement than would be believed, although at the present time the wide use of properly treated materials has done much to eliminate it. It is to be hoped that it will finally disappear and we will no longer be asked to believe that all fractures in service are due to crystallization of metals under vibration.

Another persistent idea is that trouble in service is generally due to the material and that a change in material will overcome the difficulty. In some cases this is true, but it is well to make sure that the trouble is not due to some other cause. Many cases of breakage, as has been mentioned, may be due to faulty design and no change in material will help. The modulus of elasticity is practically the same for most steels, and in cases where this is a factor it can be seen that a mere change of steel can be of no assistance. This point has been noted time and time again in crankshaft construction, where alternating stress is a factor.

In making changes in material, the shop conditions should be taken into account or trouble in production may result. As an example, consider a shaft made from steel of such a nature that after case-hardening the core

remains soft enough to allow the required straightening. A stronger core seems desirable and other material is selected, without reference to shop conditions, in order to produce this result. As soon as the straightening operation is reached it may be found impossible to carry this out without breaking the shaft. Some shafts may appear to straighten properly, only to break in service on account of almost invisible cracks which have developed. In many cases the shaft will be found to break under far lower loads than were used to bend the softer material. Similar cases will occur to the mind of the shop man, but these will serve to illustrate the point that if a radical change in material becomes desirable, manufacturing conditions should be taken into consideration.

Tool steel is one of the materials of greatest importance in manufacturing, and here, too, trouble is frequently laid to the material, and the effort is made to find a different or better steel. In some cases an improved material may give better results, but this does not necessarily mean that improved material will permit wrong treatment. This point will be discussed later in more detail.

In considering the choice of material in this way it is assumed, of course, that the material is in the best possible condition; commercially, material that is actually defective would hardly serve under the conditions expected. In the greater number of cases such defective material is quickly found by inspection, by testing, or by comparison with material known to be in good condition.

Field for Standardization

With multiplicity in the types of steels owing frequently to the selection by different mills of special types, it sometimes becomes difficult to make a choice. Here would seem to be a field for standardization even as the carbon steels have been standardized. In many cases it should be possible to determine the best steel for the particular construction, taking into consideration both cost and quality. If two steels give practically the same results under the same conditions, the cheaper should be brought forward. This does not always mean the cheaper in first cost, for the cost of handling and treatment may be high, a factor which is sometimes overlooked. The necessity for standardization and simplification is particularly true for tool steels. The functions of the various tools are well known and it should be possible to develop a few types which are particularly adapted to the work required. These conditions should not serve to obstruct research on improved materials, but should make the object of such research more pointed.

The choice of extra strong materials becomes necessary when lightness and elimination of excess weight are required, as in airplane construction, and it is worth any expense. Even here, however, and also in more ordinary construction, there is a limit to the reduction of weight or size which can be made in many parts on account of other factors. The whip of a propeller-shaft in automobile construction may serve as an example. In cases of this kind, the extra strength is of no value and there is no object in paying the extra price for the extra strength. Many designers play safe by selecting alloy steels for construction in practically all main parts, even though cheaper steels have served well in similar designs for years. Wherever this condition exists, we have a waste of material. Standardization of steels for various constructions would seem to be well worth while, and with the cooperation of the mills should not be hard to obtain.

The various grades (each grade having its peculiar properties) or so-called tempers of carbon steels entering largely into automotive construction, require some mention, although this is covered in detail in most textbooks.

Carbon steels are usually graded according to their carbon content and may be divided roughly into three classes: Low carbon from 0.10 to 0.25 per cent, medium from 0.30 to 0.55 per cent, and high carbon from 0.60 to 1.50 per cent. Low carbon steel is most frequently used in forgings for case-hardening and for automatic screw machine work in the form of cold-drawn bar stock, the cold-drawing giving better machining quality. Screw stock, containing about 0.12 per cent sulphur, is used when low carbon is required together with rapid machining qualities, as it is often difficult to obtain any great speed in machining low-carbon steels. Forging stock in the lower carbons is heat-treated in different ways to improve the machinability.

The grade between 0.30 and 0.55 per cent carbon is generally used in forgings for structural parts. The high carbon steels are used where great hardness and strength are required, as in tools.

Inspection of Materials

Variations in the carbon content and treatment of steels produce widely varying results. When the material is received, inspection and testing are usually necessary to insure proper condition and composition. Special knowledge and experience are required for this work, which requires the elimination of all troublesome material before production is begun. Especially at the present time when the mills are overcrowded it is necessary to inspect and test steels received. Materials which were suitable under only the most ordinary conditions and which had almost disappeared from the market are reappearing. One material of this nature is busheled scrap, made by piling scrap in bundles, heating, squeezing, and rolling. This will stand little or no cold bending, and even under hot bending or twisting will break into sections along the original lines of contact. Such material may be satisfactory for some purposes but is certain to make trouble if introduced into production in the place of high-grade steel. Under the microscope this material has the appearance of poorly made wrought iron, full of slag and oxide.

Bar stock for forgings should be carefully inspected for pipes and seams; better still, if possible, in the billet, where they will be more apparent.

In certain alloy-steel forgings of rather high-carbon content surface cracks may occasionally be found along the flash line. In many cases they are so shallow that machining will readily remove them, but at times they may be too deep or be the cause of hardening cracks on quenching from high temperature. When trouble occurs, a careful inspection of the forgings should be made to insure the absence of such seams.

Cold-drawn bar stock sometimes contains slivers due to the formation of surface seams in the hot rolling. If case-hardened without machining slivery sections may chip off, spoiling the part. These can usually be detected by inspection of the bars. At times other troubles, usually owing to the condition of the surface, may develop, necessitating careful inspection.

The inspection of sheet metal is an art in itself on account of the many uses to which the metal is applied and the many varieties which are made, so that no attempt will be made to cover this in great detail. The manufacture of sheet metal has improved to a decided extent in the past few years and a large proportion of the product

will be found suitable for the work desired. With cold-rolled sheet metal for deep drawing the principal trouble has been lack of ductility owing to improper rolling or annealing, or to the presence in the metal of a coarse-grained structure developed by the rolling and annealing treatment. No trouble should occur with sheet metal that is fine-grained and which has been properly annealed, provided the metal is not overstrained in the operation. The amount of draw is, of course, limited by the ductility of the metal, of which the reduction of area is a measure.

If fracture occurs in a deep-drawing operation a measurement of the reduction of area at the point of fracture will usually enable the cause to be traced. If a high reduction is found, then the metal must be in good condition and the cause may be the application of stresses beyond the power of endurance of the metal, or, in other words, to too great a draw in the operation. At times, with high reduction, fracture may occur in some definite position. This may be caused by the use of too sharp corners or edges on the tool, throwing all the strain at such points. Where local fracture occurs frequently with high reduction of the steel, in drawing or rolling sheet metal, examination of the tool should be made to locate any possible faulty design. As large radii as possible should be used.

When composition and condition are of special importance and materials must be up to certain specifications, inspection becomes more complicated and chemical analysis, physical tests, and metallurgical examinations may be necessary. Composition is usually determined by chemical analysis and on account of certain factors affecting the uniformity of the material special care is required in sampling. Particularly in the case of forgings, care should be taken to get below any decarburized layer which may exist on the surface and also to avoid any segregated areas which may occur, particularly at the center of the piece. Where millings are taken it is safest to remove the surface metal to a depth of about one-eighth inch. Careless sampling may be the cause of considerable uncertainty or of actual trouble. Alloys, particularly bearing metals, are frequently segregated and it is sometimes necessary to take samples at various points, mix, melt, and cast, taking the final sample from this casting.

Gray-iron castings require special care in sampling for analysis on account of wide variation in section and in casting conditions. At times it is possible to cast test bars from the melt or attached to the casting which will be satisfactory for sampling. When the casting is made in large quantity or is valuable and would be destroyed by sampling, this method is decidedly useful. Gray-iron castings should be inspected for hard spots, sand holes, pitting and off-centered coring. Variations in the wall thickness of certain castings may cause difficulty in machining the thinner side where the combined carbon will be higher.

Physical Testing of Steels

To determine the condition of the metal some form of physical test or possibly microscopical examination, is usually required. There are various forms of physical tests, all of which are well known; transverse, tensile, torsion, compression, alternating stress, shock, Brinell, scleroscope, and others of special nature. For speed and simplicity the Brinell test is one of the most satisfactory, specially when checked by occasional tensile or torsion tests. Certain steels may contain segregated areas of free ferrite or pure iron. Tensile test pieces containing such areas may give lower results than should be expected from the steel. Such segregated areas, although possibly showing up prominently in the test piece, usually have little or no effect upon the actual service of the steel. In cases of this kind, especially in shafting, the Brinell test will usually give more accurate results than can be obtained by the tensile or torsion test. After the proper comparisons have been made between Brinell hardness and tensile or torsional properties, the Brinell test may be used for quick and accurate results.

The scleroscope test, although widely used, has a rather limited field, giving its best results with hardened or heat-treated alloy steels. A smooth level surface is required for any degree of accuracy. On heat-treated carbon steels of forging grade the scleroscope test does not usually give satisfactory results, possibly on account of the small space tested or because of inability to meet all the necessary conditions. In many cases decidedly wide variations in results may be obtained, even from tests made at points in close proximity.

At present all important forgings are or should be heat-treated after the forging operation. In many cases this treatment is necessarily carried out before the material is received, so that determination of the condition of the metal to check this operation may be required. In the case of alloy or higher carbon steels, Brinell or other physical tests will usually give information sufficient to determine the condition of the metal. The heat-treatment of the lower carbon steels, especially when a wide range in carbon content is permitted, cannot always be determined so easily. A microscopical examination may be necessary by which it may be readily determined whether the material has been properly heat-treated. Such examination can easily be made part of the routine testing, and in all cases will be found to serve as a valuable check.

Another form of test, often of great value in giving information not found in other ways, is the shock test. This may be made in several ways, by the fall of a pendulum of known weight through a graduated arc, or by the drop test, in which a known weight falls through a known distance. This latter method is of value in testing many forms of steel, rails, bars, and structural steel for example. A measure of the ductility may be obtained by measuring the deflection or elongation obtained. A row of prick punches separated by a standard distance and located on the under side will serve as points of reference to determine the elongation.

The shock test is of value in distinguishing between different steels possibly having the same tensile properties, and between different treatments. It can be made of value in testing case-hardened work, but care must be taken not to harden more than 25 per cent of the cross-sectional area, and for comparative purposes, the depth of case must be the same.

Alternating stress is a prominent factor in many constructions, and endurance tests covering this should be made when necessary. The endurance of steels and the action of certain designs under stresses of this kind should be known before the parts go into service. This test can be carried out in various ways according to the existing conditions. Perhaps the most convenient method, one which is suitable for many classes of work, is to rotate the test piece holding one end firmly and loading the free end with weights to give any fiber stress desired. The number of revolutions before fracture can readily be determined by the use of a counter which is automatically disconnected when rupture occurs.

Standardization and uniformity of composition and condition are necessary for rapidity of production in the shop as well as to insure proper structural conditions. Steels that are too hard will cause excessive wear on the tools and the speed of machining will be lowered. Steels that are too soft may also be the cause of similar conditions. The metal tears, the cutting edge becomes dull, and the tool commences to slip, hardening the surface under its pressure, an effect similar to that caused by cold rolling or drawing, until further work becomes impossible. When this occurs, annealing of the part to soften the surface thus hardened will usually permit completion of the operation.

Drilling operations in particular require a comparatively narrow range of hardness for the best results. The operator is often misled by this surface-hardening effect and considers the steel to be too hard. It is necessary to distinguish between these two conditions in order to apply the proper remedy. Annealing or heat-treatment may be required. If the trouble is caused by too high-carbon content in the steel, it may be necessary to discontinue its use. One of the valuable features of chemical analysis and inspection lies in its ability to detect material in unsuitable condition before it reaches the shop.

Uniformity of Composition

Some troubles in machining may be caused by tools faulty in composition, treatment or design. Cutting angles must be adjusted to the requirements and set-ups properly arranged. At times under stress of heavy production greater speeds and feeds can be used than advisable with the material to be machined. Tools which are too soft are occasionally the cause of considerable trouble. Before blaming the material it is sometimes well to look into these other factors. Comparison with material known to be in satisfactory condition or with other tools which are giving good service will frequently detect faulty conditions.

Little trouble on account of the material may be expected in machining alloys such as the ordinary brasses and bronzes. Aluminum may cause some trouble owing to its softness, but is not frequently used, the eight per cent copper alloy, which machines easily, being substituted.

Machining troubles on account of obscure causes may appear from time to time in the shop, and it is one of the duties of the metallurgist to trace such difficulties to the source for the purpose of elimination. In many cases the cause is more easily found than stopped, and when the use of the material is necessary, the cooperation of the shop may be required. When some soft material has accidentally found its way into the shop and must be used, it is sometimes hard to convince a force working on a bonus basis that the only remedy is in slower speeds and feeds.

Before or after machining, certain parts require heat-treatment or hardening and the metallurgist should be directly responsible for the proper carrying out of these operations.

Heat-treatment operations before machining are usually carried out to remove the worst effects of the forging heat or to prepare the material for subsequent operations. The treatment may be simple annealing, but generally consists of a quenching operation, followed by a drawing or annealing operation. Parts for structural purposes, crankshafts, for example, usually receive no further treatment after machining. Other parts require further treatment, either a simple quench and draw, or carburizing and hardening. When parts are treated before and after machining the first quench is usually high in order to effect a partial breaking down of the forging structure. The procedure used in tempering gears may serve as an example of such treatment.

The operations are usually: Quench from a temperature well above the hardening point; anneal; machine; quench at the hardening point; and draw

When quenching from the higher temperature care should be taken to remove the parts from the quenching medium while hot in order to avoid hardening cracks. These should not occur on quenching at the hardening temperature.

Methods of Carburizing

Parts designed with bearing surfaces are surface hardened in some cases by quenching from a cyanide bath, but usually by carburizing, reheating, and quenching. For this operation the lower carbon steels are used in order to obtain a soft, ductile core in combination with a hard surface. Carburizing is now carried out with various combinations of chemicals and carbonaceous material such as charcoal. The commonest forms contain a mixture of barium carbonate, limestone, and soda ash in varying proportions. At the temperatures employed the carbonates liberate carbon dioxide, this immediately reacting with the hot carbonaceous material to form carbon monoxide, which acts as the carburizing agent. To these reactions these chemical carburizers are supposed to owe their properties. After cooling carbon dioxide is reabsorbed on exposure to the air, making possible continuous use of the material.

The principal requirements of a carburizing mixture are lightness, the lighter the cheaper when bought by weight; porosity to permit rapid heating; mechanical strength; and good lasting power. Shrinkage is another factor requiring consideration, but this is usually taken care of by the continual reuse of the material through which the shrinkage finally becomes constant. The usual loss is about 20 per cent after each run, which should be replaced before reusing.

With the introduction of chemical carburizers the use of bone and charred leather is decreasing. Practically all the chemical carburizers on the market, which are made according to the requirements mentioned, will give good service. Troubles caused by improper handling in hardening are often thought due to the carburizer, and much time and energy are wasted in trying different materials. Sometimes difficulty in carburizing will be caused by improper handling of the carburizer. For example, it is often forgotten that time is required between heats for the carbonates to regenerate, and the immediate reuse of the material is frequently the cause of a slowing up of the carburizing operation. When proper precautions are taken, seldom if ever will the carburizer be found at fault when trouble develops in the hardening operation.

Kinds of Case Required

In automotive construction two kinds of case are required, light and heavy, the latter usually when grinding is to follow. The proper depth of case for these for most requirements is from 0.020 to 0.030 in. for the light and from 0.040 to 0.050 in. for the heavy case. In rare circumstances will it be necessary to exceed these limits. When deeper cases are demanded it will frequently be found that a rearrangement of the design or a more careful regulation of the straightening process will permit a lighter case. Often it will be found that far lower depths of case are being used in practice than called for

by the blueprint, with no development of trouble. Case-hardened screw-stock transmission gears with a depth of case of about 0.008 in. have given good service on cars of ancient vintage for years, with practically no signs of wear.

The cost of unnecessary depths of case may run into high figures, and the rule should be to carburize to the least amount necessary. The depth of penetration should be carefully controlled by time and temperature. The use of check pieces to determine at intervals the depth obtained will save many dollars. Such pieces should be packed near the center of the box or in some position where average results will be obtained. They should be made comparatively small in order to permit easy fracture. Sizes between one-quarter and one-half inch thick are the most convenient. If properly placed in the box, the difference between the size of the test piece and the size of the work will not cause any difference in the depths of penetration obtained although there is a popular idea to the contrary.

The depth of penetration in the carburizing process is a function of time and temperature, the effect of the latter being more important. The rate of heating, dependent on such factors as the size of the pot, kind of carburizer, and the calorific value of the fuel employed to heat the furnace, has of course an effect upon this, but when the conditions are uniform, time and temperature are the factors to be considered. The higher the temperature and the longer the time, the deeper will be the case. For economy temperatures as high as possible must be used. The possible depth is limited, however, by the temperature effect upon the grain size of the core and case. With high temperatures the carbon content of the case may become excessively high, causing chipping off in hardening or in grinding. The best results are obtained when the carbon content at the surface is kept as near 0.90 per cent as possible. When the deeper penetrations are sought the carbon content will generally be higher, but it can easily be kept below the danger point.

Treatment After Carburization

After the carburizing operation, the treatment is generally the same as employed with high-carbon steels, unless a double treatment is required to refine the core; this double treatment distinguishes the handling of case-carburized work from that of high-carbon steels. The refining point of the low-carbon steel core is higher than that of the case and the first step in the treatment is to quench from this higher temperature. In addition to refining the core, the case is brought into better condition for further treatment. Another method of treating carburized work is to quench directly from the pot, a means of obtaining good results applicable to certain classes of work. Attempts have been made to discredit this method, but nevertheless satisfactory results have been obtained for many years by its use. For the best results and in most cases it is necessary of course to reheat and quench to refine the case, although there may be exceptional conditions which require its omission.

Certain thin parts, bicycle-head shells, for example, which are forced into position in assembling, become too brittle on rehardening. On a thin part of this sort, the surfaces take on a high degree of hardness, although quenched from a high temperature, and will be found to be extremely tough. In many cases when reheating to a high temperature would not be permissible owing to the formation of scale, quenching direct at the proper temperature followed by rehardening when necessary will give good results. Tests have shown that the material is usually tougher after such treatment than when cooled in the pot and rehardened. Ball cups, ball races and similar parts may be treated in this way. The work will be clean and free from scale and at the same time the grain growth which usually occurs in both case and core on slow cooling will be checked by the quenching operation. Care must be taken to hold the carburizing operation at the proper point, which is dependent upon the nature of the steel.

The treatment for refining the core is frequently omitted, especially on large parts, and the hardening treatment is given directly after carburizing. The treatment, which is the same in both cases, is also used for hardening high-carbon steels. This operation requires careful watching on account of the many factors which enter into the success of the treatment. The alloy steels, which are usually quenched in oil, should harden properly, the quenching medium permitting quite uniform results. With the carbon steels and when glass hardness is required, water is used as the quenching medium. This requires greater care on account of certain properties to be indicated. The temperature should be properly controlled as only a small range is permitted. If the temperature is too low, the work will not harden; if too high, glass hardness cannot be obtained if the section is of any size. The rate of cooling is one of the main factors in obtaining glass hardness, and it is obvious that the higher the temperature of the work the lower this rate will be.

Water vaporizes at a comparatively moderate temperature so that it is necessary in hardening hollow or irregular sections to take great care to avoid the formation of steam pockets which may keep the water from reaching the surface of the steel, thus preventing any quenching effect, and in such cases spots or even quite large areas may be found to be dead soft. These areas may sometimes be detected by their color. When these steam pockets are of common occurrence, as for instance in hardening camshafts, it will be necessary to harden the piece in a special manner. The circulation and flow of the water should be increased, and the part should be moved vigorously or given a spinning effect on quenching. Fixtures for quenching are frequently required for the best results. Small parts quenched in quantities may require the same treatment. The amount of water required may often be reduced by proper equipment, resulting in a considerable saving.

Errors in Overspeeding

In all hardening operations time is required after bringing the work to the proper temperature to allow thorough soaking of the steel, or incomplete hardening may result. Overspeeding the operation may cause serious trouble from this and from other factors. The hardening furnace should be carefully controlled and no overrunning of the hardening temperature should be permitted or else the scale produced may be troublesome and the work left in poor condition.

It is very difficult to produce a neutral atmosphere under certain gas furnace conditions, and soft spots may develop when gas is used as fuel owing to the excessive scale produced. In such cases preheating and holding the work in the furnace as short a time as possible often permit successful carrying out of the operation.

The factors mentioned apply to tool steel, possibly even to a greater degree, as a clean, glass-hard surface is an essential in most tools. Punches and dies which are not hard will wear out rapidly, and considerable loss may

result from improper handling either through the excessive repairs required or the complete loss of the tool. Many tools require considerable preparation with a cost far higher than the original value of the steel, all of which is wasted with the loss of the tool. Careful handling and avoidance of hurry in the operation are required. Time saved by raising the furnace temperature may be more than counterbalanced by the time lost in operating with the tool. Carbon steels of the higher ranges, say from 1.20 to 1.50 per cent, may develop soft surfaces from the use of high furnace temperatures even at the start when the work is comparatively cold, owing to the formation of graphite in the surface layers in contact with the hot gases, or because of the decarburizing effect of the furnace gases upon the steel. Tools may be handled rapidly and properly by preheating before introducing into the furnace, holding this at the proper temperature.

When tools are of complicated shape, special apparatus is often required for the quenching operation. Partial hardening to avoid cracking or warping is often required, and lack of proper equipment frequently taxes the ingenuity of even the most experienced workman. Streams for interior hardening and sprays for surface hardening should be available. When much of the work is of the same kind, fixtures for quenching will be found of value. It is almost impossible to harden interior surfaces or hollows in the regular manner. Steam pockets are almost sure to form and in some cases the hardening effect will be so irregular that fracture may occur through the excessive internal strains produced. A heavy stream of water forced against the surface will usually give excellent results. Special methods of quenching will often allow proper hardening. Deep drawing dies, swaging dies, and rivet sets are examples of tools requiring special handling.

The treatment of high-speed steel is an art in itself. On account of the high temperature required, 2100 deg. fahr. or more, and the necessity for judging this by eye in continuous working, considerable attention must be paid to all the essential details. For pieces of any size preheating is essential to avoid scaling or cracking because of exposure for any length of time to the high temperature. Various quenching mediums are used, oil most commonly. When the tool is of complicated design, susceptible to cracking, molten lead at a temperature of about 800 deg. fahr. will give excellent results. The final heating should be carried out rapidly and all the fuel which can be properly burned supplied to the furnace to insure this. For special tools, as for instance twist drills, special furnaces must be provided.

After the hardening operation, tools, especially of carbon steel, are given a drawing treatment at a low temperature in order to remove strains. This operation is of value with tool steel, and in some cases with carburized work of complicated design or with sharp corners liable to chip after hardening. It will by no means correct the results of improper handling in previous operations, and for carburized low-carbon steel will usually have little or no value, although it is frequently mentioned as a cure-all.

Types of Pyrometers

In touching upon the principal requirements for hardening, stress was laid upon the necessity for proper temperature control. It is not necessary to go deeply into the subject of pyrometry, full details being available in many publications, but, as exact temperature control is so vital in practically all hardening, mention must be made of certain features of pyrometric control necessary for its proper functioning, but often neglected. There are many kinds of pyrometers ranging from the wet finger to the highly developed potentiometer recorder. The principal requirements for hardening work are accuracy, endurance, and suitability for the operation to be carried out. The principal types are the water pyrometer, the resistance pyrometer, the optical pyrometer, the thermocouple pyrometer, and mixtures of chemicals with known melting points.

Each type has its special uses, but the one most commonly used is the thermocouple. The apparatus has two parts, the thermocouple which is affected by temperature changes, and an instrument to measure the effect obtained. The thermocouple consists of two dissimilar metals, usually in wire form, welded together at one end, called the hot junction, open at the other end, called the cold junction. On completion of a circuit through the measuring instrument the pyrometer is ready for use. When the hot junction is heated a current of small magnitude, dependent upon the difference in temperature of the two junctions, will flow through the circuit. For exact readings the temperature of the cold junction must be known and properly controlled. For uniform results this point is frequently located in the ground far enough from the furnace to avoid its heating effect. In many installations the cold junction is neglected and exact control in such cases is impossible. The use of compensating devices will often eliminate this troublesome factor.

The couples themselves must be uniform in composition and condition. Any variation from such uniformity may be the cause of the formation of a point at which metals of a different nature are in contact, the result being a secondary thermocouple effect with any variation in temperature along the couple. Secondary currents of this nature are called parasites. Thermocouples should be carefully checked before use, heating the same length as used in service. The indicating or recording instruments used must be carefully cared for. All contacts must be kept clean in all types of installation where the resistance of the circuit affects the reading. Dirty switches may be a cause of large errors. An inaccurate pyrometer is worse than none on account of the misleading results. Workmen who are supplied with inaccurate equipment soon come to consider the pyrometer as valueless and will not use it. The couple should be properly installed so that the actual condition of the work will be covered.

Operations on Hardened Work

After the hardening operation much of the work is ground. Care is required in this operation to avoid softening of the work and grinding cracks, such troubles usually following too strenuous grinding operations. If the wheel is too hard or the speed too high or the cut too heavy, cracks and soft spots readily develop. Dry grinding is a fruitful source of such troubles, and wet grinding is usually to be preferred. When dry grinding cannot be avoided, care should be taken to make light cuts, using a soft wheel at a reasonable speed. Grinding cracks are often thought to be due to improper hardening, but this is seldom the case. It is true that an excessively high-carbon content in case-hardened work will cause grinding cracks to form and care should be taken to avoid this condition. With this exception, usually no condition that can occur in a well-regulated hardening room will be responsible for cracking in grinding. Under proper conditions of design and treatment hardening cracks will seldom occur. When found only after grinding it is usu-

ally certain that the fault lies in improper handling in this operation, which is not one that can be hurried. In certain parts, such as camshafts, where some areas unavoidably receive rather heavy cuts, grinding cracks and softened surfaces are of common occurrence. In such cases the operations must be regulated to the work. Fine surface cracks may generally be removed satisfactorily by a light cut at slow speed.

Inspection for hardness is carried out by scleroscope or file test. The latter gives excellent results if used with judgment, and is useful for inspection of work before and after grinding. Distortion and shrinkage occasionally occur, and careful inspection should be made to determine the fault. At times apparent shrinkage or expansion may be due to errors in the machining operation, as in the case of a valve-lifter roller in which a ¼-in. hole was said to expand at one time, and to shrink at another, on account of the effect of the hardening operation. Inspection showed that the cause was a variation in the size of the tools.

The treatment of tools is a subject in itself. Mention has been made of some of the conditions required for the treatment of tools, noting the similarity in treatment of hardened steels in general. The requirements for grinding are the same as given for case-hardened work. Faulty conditions frequently in the steel being blamed, much more expensive steels, even including high-speed steel, are tried out at considerable cost with no success, as the only remedy is proper treatment. Improper hardening or grinding may readily spoil a tool and when trouble occurs it is always well to examine the conditions of handling and treatment. If no fault can be found in the treatment, then the remedy may lie in a change of steel. File testing for hardness will often locate the cause of trouble and should be a part of the routine of tool manufacture. Many tool designers neglect the factor of design. A desire for convenience in setting up frequently leads to the insertion of tapped holes near the surface or worse still near corners, and the resulting fractures and spoilage are blamed directly on the hardener, whose only defense against such conditions is to fill the holes with clay. The amount of clay which can be inserted in a small hole is limited, and of little or no help when such holes are near the surface. Immediate change of design is a good rule to make when such fractures are found.

Selection of Equipment

The equipment of a hardening room, furnaces, lead pots, quenching tanks, and mechanical apparatus must be carefully selected. The furnaces should be proportioned to the work required as far as possible and should be uniform. In larger furnaces, pyrometer equipment to cover different portions will insure uniformity. The value of mechanical furnaces, except for special conditions, is dubious. Many a mechanical furnace which gives satisfaction in one plant, or for one operation, is found to be a failure in another, although for large pieces, or for pieces requiring special hardening in quantity, such furnaces may be essential. Mechanical furnaces of the type in which the work of any size moves from one end to the other must usually be quite large, and regulation of the final temperature becomes difficult. The mechanical apparatus requires power, and may get out of order, and so it becomes necessary, if production is to be constant, to have auxiliary furnaces, or else to be able to remove the mechanical equipment, permitting the use of the furnace in the ordinary way. In considering any type of mechanical furnaces for ordinary work, it will be well to know that it is giving satisfaction under similar conditions. Again, furnaces satisfactory from the mechanical standpoint may be a constant source of annoyance or of excessive cost on account of the irregular results obtained.

One form of furnace which will give good results on certain classes of work is the lead pot. For handling fair-sized pieces in quantity, with speed and accuracy, it is satisfactory. In hardening case-hardened work, however, great care is required. The pot should always be covered with charcoal or molten salts, as the fumes given off under oxidizing conditions are poisonous, and also because under such conditions the lead may become contaminated with lead oxide, which readily removes the carbon from the surface of the steel, thus preventing surface hardening. Steel, in a dirty lead pot, has been known to have been decarburized 0.005 in. in a few minutes. Soft spots may result from lead sticking to the work, especially when double treatment is used, the heavy scale holding the lead and preventing action by the quenching medium.

Preheating is required before inserting work in lead pots, in order to prevent freezing of the lead to the cold surface, and also to keep the temperature more uniform. A good form of equipment is a small preheating furnace heated by the waste gases from the pot furnaces, with a lead pot on each side, one at a temperature slightly below the hardening point, and the other at the exact temperature required. The work is moved at regular intervals from the preheating furnace to the first pot, and from this to the second pot. The most unfavorable feature of using lead is the short life of the ordinary pot.

For drawing operations around 1000 deg. fahr. requiring great uniformity, the lead pot is useful. For the sake of uniformity in drawing, different forms of baths are used, the oil bath for temperatures up to 550 deg. fahr., the nitrate bath, consisting of a mixture of potassium and sodium nitrates, for temperatures up to 900 deg. fahr., and the lead bath both for temperatures up to 1250 deg. fahr.

Application of Bonus System

Another matter outside the realm of actual manufacturing requires careful handling because it touches the pocketbook, and that is the payment of a bonus or the application of a piecework rate in the hardening room. Unless properly restricted, the introduction of a bonus system may cause serious trouble. There is a definite limit to the amount of work that can be properly handled in a furnace, and any attempt to hurry the operation may lead to defective parts. The higher the temperature the more rapidly the work will be turned out and frequently the furnace operator will run at as high a temperature as he dares. To some it may seem that the installation of recording pyrometers will check this tendency, but a piece of mechanism may easily be fooled at times. In one case an operator was turning out a quantity of work seemingly impossible. His records were good, the pyrometer was correct, everything seemed all right. A watch was placed upon the furnace and it was found that he had acquired the trick of pulling the thermocouple out of the furnace to lower the readings. In such cases the payment of a bonus is only an encouragement to lower the quality of the product, and much trouble can be traced to this source.

It is sometimes stated that all this can be avoided by limiting the output, but is not this, on final analysis, equivalent to the use of an hourly rate? When regulation is exact, as, for instance, with central control, or with lead-pot work, it may be possible to set a standard

to avoid loafing, but this is far from a real bonus rate. This discussion may seem outside the realm of the metallurgist, but the connection becomes more apparent when it is remembered that he is usually responsible for the elimination of difficulties. It is obvious that anything which encourages faulty production only adds to his task unnecessarily, not to mention the damage that may be done.

The production of hardened work is a highly technical operation which should be directly under the care of the hardening-room foreman and the metallurgist who are usually responsible for the methods of treatment and handling. Is it not better, then, to encourage the devising of time and labor-saving devices or the presentation of suggestions for improvements? Production may often be increased by enlargement of the furnace or by some change in the methods of handling. Rarely can it be done successfully by speeding up the furnace operator.

In every factory is a place, usually kept in the background, which should be familiar to the metallurgist, and that is the scrap pile. Large savings are frequently made by locating and stopping intermittent troubles, the results of which may not appear until the scrap pile is reached. Parts returned from service should be carefully examined to find any indication of faulty handling. In many factories the adoption of this inspection has been found to be well worth while.

Author's Conclusion

In this article an attempt has been made to show the connection between metallurgical and factory work. All the special methods of the laboratory, as well as the scientific knowledge of conditions which make uniform results possible, may be needed at times to assist production. Through its special field of research great progress is often made. New processes, materials, and methods are constantly required and what is scrap today may be of use tomorrow. The work itself should bring close touch with outside conditions under which new developments are constantly occurring. New materials, equipment, and methods from outside sources constantly come to the attention of the laboratory for testing. Some are adopted, others show defects and are rejected. In many cases preliminary tests will save expensive experimentation in the factory.

Much of the metallurgical work in a factory does not show on the surface, although the elimination of trouble may bring it out prominently. Under smooth running conditions its results may not be noticed, or may occasionally seem a waste of time and energy. The fact, nevertheless, remains that the best indication of its proper functioning is the comparative absence of trouble in manufacturing operations which come under its scope.

The Discussion

Chairman C. C. Hinkley:—The object of this class of paper has been to bring before us the tremendous technique involved in the detail of manufacturing. It is to bring home to the manufacturer and the man at the head the amount of knowledge necessary to keep production running smoothly, and why it is that when production is running most smoothly a manufacturer can be sure that his laboratory is most efficient.

Is there any way of picking out mixed stock? For instance, if a large shipment of mixed steel in all the sizes and shapes is thrown down on the ground, how can the analysis be identified?

R. H. Sherry:—One method for similar bars is to take a standard bar of known carbon content and place it between contacts 10 ft. apart. The unknown bar is also placed between contacts, the resistance controlled through a galvanometer, and the deflection indicating the carbon content is noted on the scale. If the unknown bar is of lower carbon content than the standard, the deflection will be on one side of the zero; if it is higher, it will be on the other side. This is a rapid method. In a day's work 20,000 lb. of steel can be picked out which might require a month or so to analyze. There are alloy and carbon steels of course that require either hardening or analysis.

A Member:—In the last Journal there was a paper by an instructor in Purdue, who described a grinding-wheel test in which the nature of the steel was shown by the kind of spark that was thrown off when it was applied on the grinding wheel. Is that practical?

R. H. Sherry:—Yes, that is practical in some ways. Of course it would take an expert man to handle that grinding-wheel test. Chrome, tungsten and carbon steels are easily distinguished, but much more complicated methods than a simple grinding test are required in a case such as Mr. Hinkley mentioned.

Chairman Hinkley:—What is the method of keeping stock in bar or strip separated as it comes into the plant, is stored, goes to the machine-room floor and is actually made into the part for which it is intended?

R. H. Sherry:—The usual method is to have a standard set of colors. The stock is usually classified in bins far enough apart so that there is no danger of mixing them.

H. M. Rice:—Has there ever been any distortion noted on account of the method of handling parts in the heat-treatment department?

R. H. Sherry:—Every steel has a normal amount of shrinking and distortion in the heat-treating operation, dependent upon the conditions. For instance, suppose we desire to harden or heat-treat forged pieces that have been purchased not already treated. After the forgings are heat-treated, there will be a certain amount of distortion not experienced before. This may be troublesome, but almost every case may be worked out for each particular part. Often it is only some change of treatment that causes trouble. We had a standard shrinkage for case-hardened gear steels, which was almost always the same. Mechanical conditions and variation in section may also have a marked effect.

D. H. Reeves:—Why is it that the softness or hardness in the grinding wheel will develop cracks in the hardened surface?

R. H. Sherry:—A soft grinding wheel can be said to be a hard grinding wheel at high speeds. The hard grinding wheel develops much more heat than a soft grinding wheel and the soft wheel develops more heat at a higher speed. The heating effect on the surface with the cold background produces the crack. A high carbon steel exterior cracks easily, because the crack simply follows along the lines of the carbide of iron around each grain, and it can break through much more easily than through ordinary hardened steel. Softening may also be caused by the heat developed, and cracks may occur in normally carburized surface by overcrowding the work.

G. L. Allen:—What causes the pitting of transmission gears? I have noticed this in high-carbon or nickel-steel gears that were hardened to about 75 deg. scleroscope, these gears having been subjected to the same loads. The chemical analysis was about the same and there was no way of determining one gear from the

other except that one was pitted and the other was not. I have also noticed this pitting on a set of integral countershaft gears. Sometimes the second-speed gears and other times the first-speed gears would be pitted. Of course we know that the gears used on the first speed are subjected to greater loads than those on the second.

R. H. SHERRY:—Primarily pitting of gears is due to too low carbon content, or to the use of too high drawing temperatures, which will result in too soft a surface.

H. M. JEROME:—What is the cause and remedy for variation in the elongation of a heat-treated part, such as a connecting-rod?

R. H. SHERRY:—A connecting-rod in a cross-grained condition will probably shrink on refinement of the grain, but I cannot understand why it should expand under proper conditions. If a piece is irregular or hollow, more or less distortion and scaling might lead to the assumption that there was shrinkage, but personally I have had no such difficulty with properly treated connecting-rods.

A MEMBER:—I have had some of the same trouble that Mr. Jerome mentions. The metallurgist, after having the material analyzed, of course said it was all the same. We had to take his word for it, but I have found in the majority of times that connecting-rods grow or shrink because the man either pulled the thermo-couple of the pyrometer out of the furnace or failed to put it in at all. We found that if we watched the pyrometer and kept the heats the same, the connecting-rods did not vary so much. It has been my experience in the majority of heat-treating jobs that the workmen do not know what a pyrometer means. They have one hanging on the wall and generally the couple is on the wall also.

R. H. SHERRY:—In answering Mr. Jerome's question, I assumed that his pyrometers were connected, properly installed and used.

A MEMBER:—Has there been any great success in working out an alloy to take the place of tungsten steel for valve heads?

R. H. SHERRY:—The main result has been that the amount of tungsten used in the head has been decreased. The high-tungsten valve is still held to by some engineers either because they know they cannot lose out on it or they are afraid to experiment, but the present tendency is as I have said, with some development in the use of other steels.

A MEMBER:—How is nickel-steel working out?

R. H. SHERRY:—They have been experimenting on nickel-steel and have put some on the market with good results.

CHAIRMAN HINKLEY:—I found by experiment that plain 3½ per cent nickel-steel is better than the low tungsten, but not as good as high tungsten.

MR. LINCOLN:—Do some steels absorb carbon more rapidly than others?

R. H. SHERRY:—A great deal has been published on the subject of absorption. From an inspection of the fracture one man will state that nickel-steels do absorb more carbon and another vice versa. In the early days of carburizing compounds, I examined about one hundred pieces a day of all kinds of steels, and as far as microscopical depth went, I never could find any difference, except in certain chrome-nickel steels. They will apparently harden more deeply. The carbon penetration under the microscope did not seem to be any deeper. But the appearance of the fracture seemed to indicate a deeper case, possibly owing to the fact that steels of this nature will harden more deeply than carbon steels.

EFFECT OF THE WAR ON MERCHANT SHIPBUILDING

The submarine campaign of the Germans has rendered it imperative that present merchant ships in existence be furnished a more adequate protection and also that ships lost be replaced at an unprecedented rate by new construction.

The large number of sinkings of steel vessels has probably abolished forever the 8-, 9- and 10-knot vessels in transoceanic trade.

The military requirements for shipping troops and supplies have made enormous demands for high-speed passenger transport vessels, which demands, so far, have been fairly well filled by British ships, but there are probably not enough available transport ships for the United States to carry to Europe more than 750,000 soldiers per annum. This growing demand for large, high-speed vessels is becoming more insistent and is bound to result in the construction of vessels of this kind.

The demand for slower freight vessels is being met in part by the construction of so-called *standardized* types abroad and by the construction of additional ships of the "fabricated" designs in this country and by the attempted construction of wooden vessels.

The standardized ship has been the dream of shipbuilding architects and engineers ever since the first steel ship was built. The best results, up to the present time, have been obtained by the yards on the Great Lakes in building ore ships for a given fixed trade with practically standard loading and unloading facilities. The standard ship has also been developed to a certain extent by individual merchant yards in Great Britain. All of the shipyards have naturally, in the course of years, built up standard methods of doing certain things, such as standard fittings, valves, flanges, drop forgings, deck and engine-room fittings of all kinds, but, except for the Great Lakes, the yards have not been able to adopt standard hulls, which is the main essential difference between the proposed new vessels being built for the Government under a most urgent necessity and vessels built heretofore to the individual taste and requirements of scattered owners.

The designs of these "fabricated" vessels are such as to permit of the use of the most modern shop methods in preparing the material in order that the minimum amount of work may remain to be done in the assembling and launching yards, but, no matter what the type of vessel to be constructed, the crux of the shipbuilding question lies in the amount of labor that may be made available for this building. Steel material, of course, is a most important factor, but there is no doubt in the minds of the men best able to judge, that the output of such material is, at present, far ahead of the shipbuilding capacity. If our shipbuilding program is to have any reasonable assurance of success it is necessary that the output on this coast, for instance, be doubled within the next twelve months.

From a paper presented before a joint meeting of the Engineers' Club of Philadelphia and the Philadelphia Section of the American Society of Mechanical Engineers, by Homer S. Ferguson, president and general manager of the Newport News Shipbuilding and Dry Dock Company.

Fabricated Bakelite Materials

By RAY P. JACKSON* (*Member of the Society*)

CLEVELAND SECTION PAPER *Illustrated with* CHART AND PHOTOGRAPH

ORGANIC bonding materials can be roughly divided into three classes: First, materials which can be taken up by a solvent and deposited therefrom by the evaporation of the solvent; second, materials which can be used in connection with a solvent or thinner, but which depend for their final hardening mainly on the taking up of oxygen from the air, or some ingredient-carrying oxygen, thereby changing their chemical composition; third, materials which, under the application of heat, change their molecular structure and pass into a permanently hard state without losing the solvent or oxidizing.

To the first class belong the various waxes, gums and asphalts. For example, gum arabic and glue take up water, and are hardened by the loss of the water. Shellac dissolves in alcohol and is hardened by its evaporation. Other organic resins, such as the gums, dissolve in turpentine, benzol, or other solvents. The list in this class is long and varied.

The second class is represented typically by what are known as the drying oils, such as linseed oil and tung oil, more commonly known as China wood oil. These oils, when exposed to the air, tend to absorb oxygen and congeal into a hard body not easily redissolved. An oil of this kind forms the base of most paints and high-class varnishes.

In the third class are but comparatively few substances, as yet, although no one knows how many may be possible. Bakelite, condensite, and other similar synthetic resins, come in this class, and it is to one of them and to some of its industrial applications that we wish to call attention.

Bakelite is a harmless and particularly inert material derived from the combination of two substances noted for their activity and power, so far as affecting organic life is concerned, namely, carbolic acid, creosol or phenol, and formaldehyde. While there are various ways of obtaining it, phenol is essentially a coal-tar derivative. Formaldehyde is commonly obtained by a special treatment of wood alcohol. The two, when combined in the proper manner, form a resin which in its primary state can be either solid or fluid, but in either case it is essentially a soft resin, easily affected by heat and solvents. The effect of heat and pressure continued sufficiently long, however, is to carry the material over into a hard state, in which it is not affected by ordinary solvents or temperatures that would ordinarily disintegrate a gum or resin. When in this condition bakelite is but slightly affected by acids or weak alkalies, but is broken up by strong or caustic alkalies. It will not burn at all readily, but will char and burn slowly at temperatures from 300 to 400 deg. cent.

Bakelite itself, when hardened, is much harder, stronger, and more glasslike than practically any other organic material. It is peculiarly suitable as a bonding material with which to build up other bodies, known as fillers, into a variety of fabricated structures.

There are two commercial methods by which it is utilized. One is to mold a mixture of bakelite and a filler into accurately formed steel molds, the other to build up plates or tubes from sheets of material that have been treated with bakelite in the form of a varnish.

With the former we are familiar in the form of ignition distributor heads, as seen on all battery and many magneto ignition devices. As used for this purpose, the filler or body is wood flour or a finely pulverized and prepared wood fiber. The different colors—black, brown, or red—are due purely to the dyes used to secure uniformity of appearance. A given manufacturer usually finds it best to standardize on one particular color. When properly molded, this product has a high insulating character, will withstand temperatures considerably above boiling water, and is practically free from shrinkage or warping. Hard rubber is the only other material which compares favorably with it, but the texture of hard rubber is difficult to control, so that it has nearly gone out of use for this kind of work on account of that reason and because of its cost.

Asbestos fiber is another filler commonly used. Asbestos adds materially to the strength of the mixture, especially against shocks or blows, but lessens somewhat the insulating strength. Such molding mixtures are now used for bonding small commutators. The usual mica is placed between the bars, but the whole commutator is put in a mold and formed bodily into a unit on a small tube mandrel, ready to press onto the shaft. Being securely cemented in place, each bar stays so put, and high bars are unknown. Other filler materials, such as textile cotton fiber, will doubtless find uses in this connection when satisfactory methods for handling them are worked out.

The molding of bakelite without filler in various semi-transparent forms is a special art, not connected with the electrical industry. Examples are pipe stems, cigar holders, bead work, and jewelry resembling amber.

The other large field in which fabricated bakelite is found is that of structures built up from treated sheets of paper or cloth. We will first consider the work based on paper. A tough, strong paper made from wood fiber, and commonly known as "kraft paper," is passed through a bath of bakelite varnish, treated on one or both sides, and is then dried by being passed up and down through a heated tower. This drives off the solvent in it, but does not permanently harden the bakelite. The paper thus treated can then be rolled up and stored indefinitely.

For tubes or hollow cylinders the paper is treated on one side only. In being formed into the tube the paper is slowly wound onto a mandril or steel cylinder, and at the same time is rotated against a heated plate or another heated cylinder. The bakelite is melted just enough to make the sheets of paper adhere tightly. When the tube has reached the required thickness the mandrel, with the tube still on it, is taken out of the machine and subjected for several hours to heat and air pressure in order to carry the bakelite over into what is known as the "C," or infusible, state. After cooling, the tube can be pressed

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off the mandrel. The traces of loose paper that can sometimes be seen inside the tubes are not part of the tube proper, but remains of the wax-treated paper put on the mandrel before winding, to facilitate pressing the tube off the mandrel. The above covers the making of round tubes.

If a rectangular shape is wanted, the rolled tube can be pressed off before the final hardening and formed to the desired shape while warm, or it can even be formed to the shape directly from the loosely wound paper. While secured in such forms it may then be given the final hardening. Rectangular tubes, channel and V sections, can be made in this way, the latter by sawing rectangular tubes lengthwise. Such tubes and channels are well suited for carrying high-tension wiring on automobile engines. In electrical construction work they are used generally for transformer insulation between the iron core and primary and secondary coils. It is suited to a great variety of structural insulating uses, for which there is no good substitute.

The other general method of fabricating this treated paper is to stack the sheets up loosely and subject them to great pressure between heated steam platens or press plates. Smooth sheets or plates are thus formed, these having a polish similar to that of the metal separators used. This material, known by the trade name of "213 micarta," can be sawed, drilled and tapped. By proper handling it can be punched up to about 3/16 in. thickness. It can be produced in thicknesses up to about 2 in., but is commonly limited to ½ in. or less. Like the tube material, it can, while in the warm but unhardened state, be molded into channel and V shapes, and even into curved tube sections in two parts, or two curved channels fitting together. Such sections make very fine protection for car wiring. In general, this material finds its way into brush-holder rings and other plate insulations for starting, lighting, and ignition apparatus. It is also used for small timing gears with battery or the magneto-type ignition devices.

The shredded refuse or waste from the bakelite-treated paper can be molded into many solid forms. If different colors are mixed, some peculiar decorative features are obtained, but so far, however, these forms have not been able to compete with wood. The little pellets suitable for valve tappets show what this product is like. The special virtues of these valve tappets are strength, comparative freedom from noise, and absence of distortion due to moisture.

We now come to the one use of a bakelite product of most interest to the automobile engineer; that is the plate material made from cotton cloth or duck and bakelite cementing varnish.

The method of producing this stock is essentially the same as that used in the case of paper plate. The product is a good insulator, but has no particular advantage for such purposes as compared with the paper plate. Its chief and particular field is as a material for noiseless gears.. Vibration, and the striking of metal on metal, are things the car builder or engine manufacturer is always fighting. This bakelite product, with a woven fabric imbedded in it; or, looked at another way, this woven fabric every particle of which is cemented together with bakelite, is an organic gear material as lasting as cast iron, but with a comparatively low modulus of elasticity.

In the transmission of power by spur or bevel gearing the impact of the teeth when meshing tends to produce noise. The amount and tone of such noise depend primarily on the character of the materials from which the gears are made. Steel, and steel or iron, meshing at speeds that produce vibrations, cause a loud, piercing, and often disagreeable sound. When brass is meshing with steel the sound resulting is of lower pitch and less piercing in tone. Brass has a modulus of elasticity less than that of steel, and therefore flexes or "gives" more at the instant of impact, thus decreasing the sharpness of the blow.

A non-metallic material has a much lower modulus of elasticity than either steel or brass, and works with still less noise. A non-metallic material, however, in order to be suitable for gears, must have a mechanical

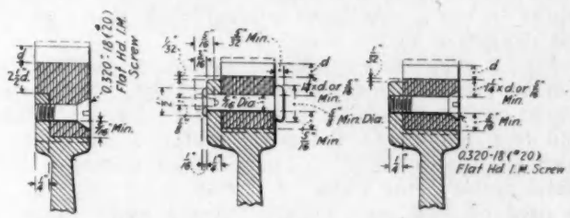


FIG. 1—CAMSHAFT GEARS MOUNTED ON METAL CENTERS

strength sufficiently high to withstand the stresses involved without requiring an unduly wide gear face. It must be hard enough to wear well when properly lubricated, and must not shrink or swell because of oil, moisture or heat, or deteriorate in storage. The teeth of the gear should withstand the service requirements without metallic reinforcement at their ends in order that the faces of the two mating gears can be made of equal width. The wear across the width will then be uniform, thus avoiding clashing of metal to metal, in case of end play of one or the other of the gears.

The material referred to previously, and known as bakelite "micarta D," meets the above requirements. It is vermin, moisture and oil proof, and will withstand temperatures up to that of boiling water.

The following physical properties of this gear material have been determined by careful tests:

Tensile strength, parallel to laminations	10,000 lb. per sq. in.
Compression strength, perpendicular to laminations	35,000 lb. per sq. in.
Compression strength, parallel to laminations	17,000 lb. per sq. in.
Transverse strength, parallel to laminations	17,000 lb. per sq. in.
Transverse strength, perpendicular to laminations	17,000 lb. per sq. in.
Coefficient of expansion per inch per degree centigrade:	
Parallel to laminations	0.000020 in.
Perpendicular to laminations	0.000085 in.
Specific gravity	1.4
Weight per cubic inch	0.05 lb.
Shrinkage, up to a temperature of 100 deg. cent.	practically zero
Oil absorption	practically zero
Water absorption, depending on the relative amount of edge surface exposed (for 50-hr. immersion in water at 21 deg. cent.) by weight	0.25 to 2.0 per cent

In general the teeth in these gears should be cut with a rotary cutter, such as found on a hobbing machine. The cutting speed should be as high as possible up to 400 to 500 ft. per min., but with a fine feed. Good

results with a fine feed have been obtained with a cutting speed of a little over 100 ft. per min. The cutting tool should have a little rake, and in general the material cuts like very hard wood. When cutting straight teeth it is advisable to back up the material with a hard wood blank to prevent fraying of the fabric when the cutter comes through. For cutting helical gears, however, if the cutter is kept sharp and the speed is high the backing-up plates can usually be dispensed with.

The material is applied on automobiles for camshaft gears, idler gears, for magneto, pump and generator drive and in some cases for the generator pinion. A generator drive with micarta D gears offers one opportunity to use a high-speed generator of small size without danger of undue noise.

Fig. 1 suggests methods of mounting camshaft and similar gears on metal centers or hubs. The micarta blanks are immersed in boiling water for five minutes and then slipped on the metal center, a shrinkage allowance of about 0.001 in. per inch of diameter of the metal center being used. A shrink fit of 0.002 in. less is used on that part of the micarta blank projecting over the back of the rim. An allowance of 1/16 in. is made on the outside and the inside of the blank for trimming to accurate size before cutting the teeth. In trimming the outside of blank a rounded corner should be given to the edges, thereby rounding the outer ends of the gear teeth when cut. The rivet hole should not exceed the rivet diameter plus 0.003 in. Riveting should be done cold on a press with a centering set to form the head, 6 tons being used for a 5/16-in. and 4 tons for a ¼-in. rivet. The rivets should be made from cold-rolled steel, annealed after the head is formed and the centering hole drilled. The size of rivets and screws shown are suitable for an 8-in. timing gear secured at six points. The size may be reduced in case the gear is smaller or secured at more points.

Gears can be made of this material to substitute directly in place of metal gears without requiring extra width of face for shrouding.

A satisfactory design of camshaft gear is also manufactured, the gear rim being molded directly onto a metal center so that no rivets, screws or projecting end plates are necessary. The surface of the metal hub is cut with a diamond knurl so as to insure absolute rigidity between the rim and hub, Fig. 2.

One big advantage of this type of construction from the automobile manufacturer's standpoint is that it is supplied with a finished bore and hub. The diameter of the gear rim can be molded to within a few thousandths of the finished size but ordinarily a light cut is taken in order to insure absolute concentricity.

The Discussion

CHAIRMAN W. R. STRICKLAND:—Our experience with micarta gears has only been to the extent of putting them to quite severe tests on one of our eight-cylinder engines that we had on the testing stand. In the tests the gears showed up quite satisfactory in regard to strength. We formerly used cast-iron gears and are now using the cambric gears, but the micarta gear, which was made from the solid block, seems to be as strong as either of these. The gears machined well and did not fray at the edges. After the test the gears showed no perceptible wear.

A. J. SCAIFE:—We have been using micarta gears for two years in a touring-car engine and to our knowledge we have not had a single set returned. We have found that they do not swell or shrink or give any trouble that we had with the old fiber gears.

A. M. DEAN:—I have noticed that while the micarta gear wears to no perceptible extent itself, it does wear the other mating gear. I have seen gears that were in service up to 10,000 miles in which the teeth of the crankshaft gear were half worn away, while the teeth of the micarta gear showed no perceptible wear.

H. C. SNOW:—Our experience with micarta gears has been quite the opposite. The first few which we tried out at the beginning of the season proved very satisfactory. After we got to producing them in quantities,

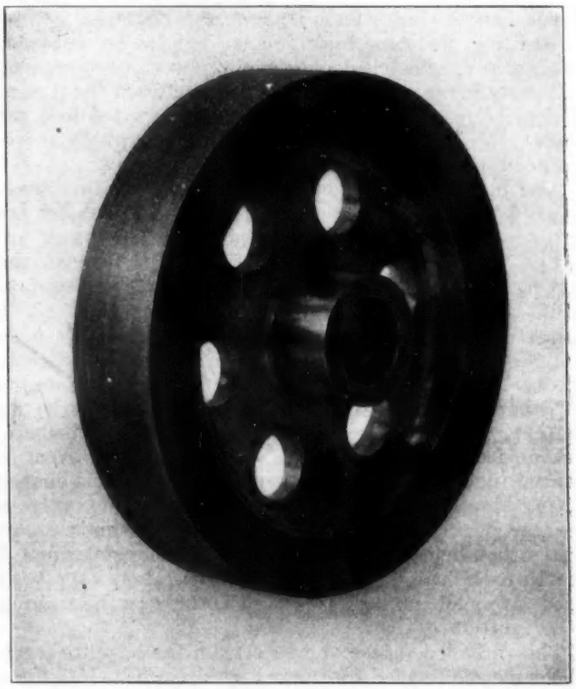


FIG. 2—SHOWING BAKELITE GEAR WITH METAL HUB

however, the gears began to strip. We replaced some only to have them also go out of commission inside of a hundred miles.

A MEMBER:—Can broken bakelite gears be repaired by dissolving?

R. P. JACKSON:—There is no way of dissolving bakelite after hardening. It is not, however, as liable to shatter as wood. Under stress it gives slowly, but tends to retain it strength after being bent, while wood will shear. It can be repaired only by a fish-plate or splicing.

CHAIRMAN STRICKLAND:—Could a broken distributer head be cemented together as a temporary job?

R. P. JACKSON:—A skilled workman might be able to cement the pieces together with shellac. Powdered shellac would have to be placed on the surfaces that are fractured and the pieces pressed together and heated to a little above the boiling point of water. The shellac would melt and seal the points of the distributer head without injuring it. This would only be a very temporary repair, because the strength would not be as great as the original material.

MR. TALLEY:—I have been working on bakelite micarta-D gears for quite a few years and have had considerable experience with camshaft gears. One point I would like to emphasize is that this material is entirely

self-supporting, the ends not requiring reinforcement. This is of importance from several considerations, the chief of which is that it allows the bakelite gear to have the same width of face as the mating gear. The wear is evenly distributed over the entire face. With shrouded gears a groove equal in width to the mating gear is worn in the face of the non-metallic material. From the standpoint of clearances it is oftentimes undesirable or even impossible to use shrouds. Bakelite micarta lends itself very well to such applications.

Another feature with reference to bakelite which will bear repeating is that it does not warp, shrink or swell. This is of especial importance in camshaft gears, for it is absolutely essential that they retain their shape under any and all conditions of heat, oil and moisture.

On the whole, bakelite camshaft gears have worked out successfully. There have been some misapplications and a corresponding amount of trouble, but where properly designed and applied they are absolutely satisfactory.

In the industrial field bakelite gears have been put to a great diversity of uses. As the main drive gear on certain graphophones and adding machines it has been a decided success. As the main drive on large steel and rubber rolls in some of the mills in the East it has been equally successful.

In designing bakelite gears for ordinary work we use a maximum fiber stress of 5000 lb. per sq. in., based on the Lewis formula.

A MEMBER:—Has the forming of bakelite pinions ever been tried?

MR. TALLEY:—We have made a mold for making a speedometer gear, but the fiber gear is so much less expensive that we could not compete at our price.

A. J. SCAIFE:—What would cause teeth stripping on bakelite timing gears after running about 100 miles?

MR. TALLEY:—I have seen some bakelite gears strip, and in every case I have been able to prove that it was only through misapplication or through some mistake. We have thousands of bakelite gears that are operating satisfactorily, but sometimes we do have such cases come up, and so far we have been able to check this trouble. I think the main trouble in these cases is the driving of too many accessories through this camshaft gear. In one instance where this trouble was apparent, the camshaft, fan, air-pump, oil-pump, water-pump and generator were driven through this camshaft gear.

MR. SMITH:—In case cast-iron and bakelite gears are used together, should the pitch be greater and the face wider?

MR. TALLEY:—That is a hard question to answer for the reason that we have apparently proven it both ways. We have customers who have replaced cast-iron gears with bakelite gears of the same dimensions and have had no trouble. We have also had customers who have replaced metal gears with bakelite gears of the same dimensions and have had a great deal of trouble. Often the angle is large and the pitch small when metal gears are used. In such cases if the service is severe the design should be strengthened. On the other hand if the metal gear is liberally designed it is perfectly safe to substitute bakelite without change.

MR. MCADAMS:—Is the practice of applying bakelite rings on the metal center by putting the rings in hot water and then putting them on metal centers with slight pressure successful.

MR. TALLEY:—Where bakelite gear rings are to be mounted on a metal hub or spider by means of rivets or screws it is good practice to heat the rings to approximately 90 deg. cent. and then press them on the hub with a slight pressure. This insures a good snug fit of the ring on the hub. It is understood, however, that the rivets or screws are depended on for the transmission of power. While it is possible to transmit a considerable amount of power by means of the press fit alone, I certainly would never recommend it for a camshaft gear.

MR. MCADAMS:—Is there any type of bakelite that will not burn?

R. P. JACKSON:—I do not know of any bakelite that will not burn. We have, however, been able to work the bakelite up to 150 deg. cent. occasionally, and it can be worked as high as 200 deg., if not for too long a period, without charring. It will begin to char quickly between 300 and 400 deg. cent. Almost all ignition sets that have a brush distributor have a rubber track on the inside to protect against burning between segments. We do not attempt to put bakelite between commutator bars, as it is not suitable for such a place. There is nothing in the way of organic material that is suitable, as there is no organic material that is fireproof.

INTERNATIONAL AIRCRAFT STANDARDIZATION

WHAT has been characterized as the most important step yet taken in international standardization is the work being conducted by the International Aircraft Standards Board at Washington. This board is composed of representatives of all the Allied countries—Great Britain, Canada, France, Italy and the United States. Its purpose is to keep all these countries in touch as regards the design and production of aeronautic material. General Manager Coker F. Clarkson and Chairman Chas. M. Manly of the Aeronautic Division of the Standards Committee have been appointed to represent the Society on the Board. The other members are as follows:

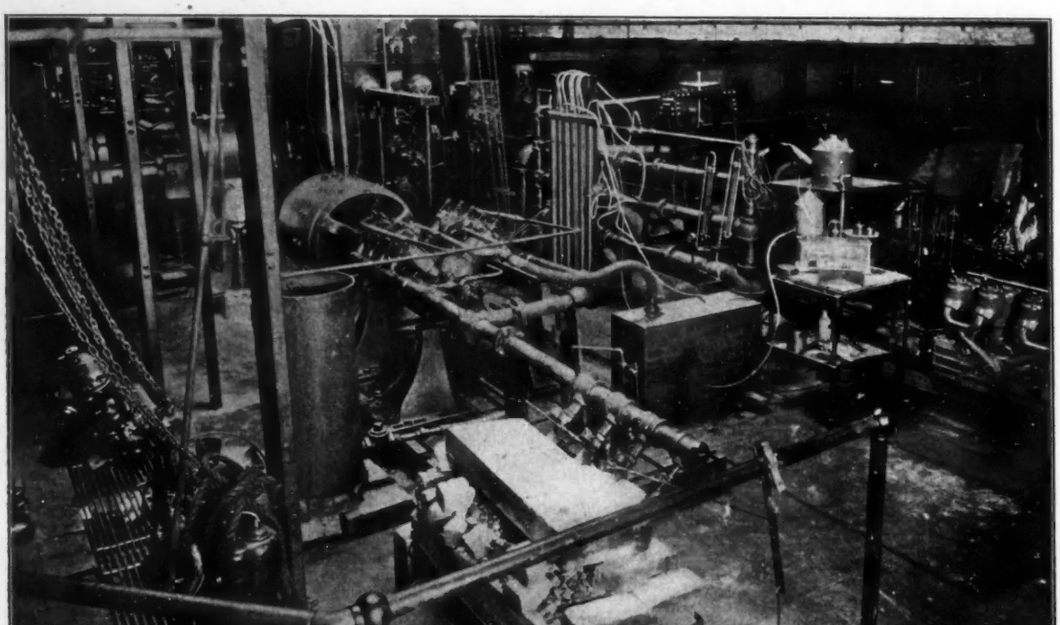
F. G. Diffin is chairman, and with G. V. Burgess, P. D. Merica, G. L. Norris and W. B. Stout represents the United States. Doctor Merica is secretary of the Board.

Great Britain is represented by Capt. A. B. Roger, Lieut. W. F. Prentice and S. G. Payne; Canada by F. G. Ericson; France by Capt. E. C. T. de Chanvalon and Lieut. U. Mignot; and Italy by Capt. F. Vizzani, Lieut. Carlo Abetti, A. Tomilio and Prof. J. S. MacGregor.

The Board is now coordinating specifications for all aircraft material. Later, if necessary, small parts will be considered. The specifications standardized by the Board will be recommended to all the Allied countries, and as quickly as possible consistent with production conditions they will be put into effect.

The regular meetings of the Board are held weekly or bi-weekly in Washington, a special organization method being available for carrying on the work between meetings. The members of the Board are keeping in close touch with the S. A. E. aeronautic standardization work in order to avoid duplication of effort.

A number of American manufacturers have been consulted in making up the specifications, so that they represent the best practice in every way. The international standards on airplane materials and fabricated parts may be obtained from the International Aircraft Standards Board, Munsey Building, Washington, D. C.



Carbureter Apparatus at Columbia University Used in Making Government Tests

Industrial Research and the Nation

THE two following papers, presented at a recent meeting of the American Institute of Electrical Engineers, indicate how closely together the government, institutions of learning and industrial establishments are working to solve scientific problems. In view of the many problems under investigation by the automotive industry a knowledge of the work being done by electrical engineers will be of value to the members of this Society.

By C. E. SKINNER* (*Non-Member*) *Illustrated with* PHOTOGRAPH

RESEARCH has been defined as "diligent protracted investigation, especially for the purpose of adding to human knowledge." If we accept this definition, we find that it covers an extremely wide field of activities. It applies equally well to the work of the pure scientist, whose primary aim is to extend our knowledge to the remotest bounds of the universe, and to the work of the industrial chemist, who by careful painstaking analyses maps out the limits of impurities which may be allowed in a manufacturing process. Between these extremes lie possibilities for research in every imaginable field, with pure and applied science so closely interlinked that it is impossible to say where the one ends and the other begins.

That there are possibilities of adding to human knowledge in innumerable ways is evidenced by the status of research today. Never before were there so many interested in research in all its branches; never before were there so many forces at work to promote research. Changing economic conditions, even before the war now in progress, made it necessary that research be carried on in almost every field of endeavor. The war has emphasized this necessity many fold. Many industrial corporations which were not provided with research facilities heretofore are making such provision and many of those having such facilities are making considerable additions, both for increased amounts and for an increased variety of research. Research departments and scholarships are being provided for in universities and colleges. Commercial research laboratories are being promoted to serve groups of industries where individually they cannot economically provide their own facilities. Scientific and engineering organizations are appointing research committees, and research organizations, such as the National Research Council, are being formed. We have research provided for by private gifts and by governmental grants. The Federal Government is constantly increasing its research facilities in its various departments, such as the Bureau of Standards, the Bureau of Mines, the Forest Products Laboratory, and the Agricultural Experimental Stations. This movement is not only national; it is international. Commissions from abroad have studied research conditions in the United States, and the United States has sent men to our Allies to study their progress in research in connection with the war. For the immediate present, progress in pure scientific research is perhaps much less than prior to the war, but nevertheless research today is in a condition of great activity. The slowing up of pure scientific research at this time is due to the fact the workers the world over are in a large

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measure engaged either in actual warfare or in research in connection with problems arising through the war. Fortunately for the future, many of the results of these war investigations will be of great value in connection with the peaceful pursuits to come after the war.

Classes of Research

For the purpose of this discussion, research may be conveniently divided into three—possibly four—general classes; this division depending upon the agencies involved and the purposes for which the work is done. These are university research, industrial research, and governmental research—and possibly philanthropic research. The first includes the pure scientific research, which naturally finds its home in the university, and all other research done there for the purpose of training men. The second includes all that done by industrial concerns or for them with the purpose of advancing industry. The third includes all that carried on by the Federal or the State Governments for the purpose of benefiting the people as a whole. Philanthropic research differs from governmental only in the fact that its funds are provided by individuals, instead of by the Government, as, for example, the work of the Rockefeller foundation. No sharp dividing lines can be drawn between these classes. They all have much in common. All should be scientific. Much industrial research is philanthropic, and many times university research leads to industrial progress. Governmental research is for the purpose of serving the whole people, and it therefore does much for education and for industry, and certainly could be classed as philanthropic. It is just as difficult, therefore, sharply to maintain these classifications as it is to maintain a clear-cut distinction between pure and applied science.

It may be well, however, to consider something of the primary function of each of these four classes, their distinctive fields and their relation to each other. The discussion which follows naturally will be from the viewpoint of one whose experience lies wholly within the field of industrial research.

The primary function of the university in research should be the training of research men. If the conditions outlined in the introduction of this paper are accepted, then it is evident that men with the broadest and best training possible are going to be required in ever-increasing numbers for every possible phase of the work. It is self-evident that the fundamental training of these men must be gotten in the university and that universities should be equipped to turn out research men just as they are now equipped to turn out men with academic and engineering degrees. It is to the university we must look for the broad, fundamental training so necessary in research. These trained men will, in accordance with their training and their fitness, find their places in pure scientific research, in industrial research, in governmental research and in teaching positions where more and more research men are to be trained. It is rather a sad commentary that the university has not been able to make its teaching positions more attractive by providing compensation more in line with that obtainable in other lines. While writing this paper, its author received letters of inquiry for several men for teaching positions—some in connection with research—with specifications which could be met only by men of considerable experience. The compensation named was very much less than experience meeting the same specifications could command in other lines. While it is generally understood, at least by those outside the teaching profession, that it has many compensations, such as short hours and long vacations, the average salary is certainly not one of these special attractions. We have splendid endowments for buildings and sometimes for equipment, but we have practically no endowment for men of genius who might make notable progress in pure research and at the same time serve as teachers and examples for the training of men for the whole field. If it takes a genius to recognize a genius yet undeveloped and properly to stimulate and direct that genius, how necessary it is that we place men of genius at the head of the research departments of our universities. A few are already so equipped, but this is a plea for a larger and a more definite program of research training and the development of that judgment which will be able to direct these trained men to the line of work for which they are best suited.

In the training of research men, facilities and problems must be provided, and the question arises as to the relation of these problems to going industrial problems. One should not be dogmatic on the subject, but the following suggestions may be worth consideration and discussion. Training should be aimed first at a broad general education. This should be such as to give culture as well as a thorough grounding in general science. Specialization should begin only after the broader foundation is laid. This specialization should be aimed at developing the research spirit, which is simply a desire for knowledge of the truth. To this end, problems should be set which will develop the latent abilities to observe facts and to overcome obstacles. For such training the exact problem matters little just so it is in the field of chosen endeavor. It may be of a highly theoretical nature, with no possible immediate industrial application. It may be for the establishment of a law, the proving of a principle, or the finding of the limits of a known law. It may be a very restricted problem, as the proving of a single phase of one otherwise well worked out. The problem should be so chosen that the really essential apparatus is available for its solution, or the problem should require that the necessary apparatus be devised.

Solution of Industrial Problems

Industrial research problems cannot, as a rule, be given over to university research departments for solution. There are many reasons for this, the patent situation being one of the prominent ones. So long as industry depends so much upon patents or upon secret processes for protection, it must carry on its vital research within its own laboratories and under its own control. Many industrial problems are also so closely related to the work daily being performed in producing the particular commodity, that any research in connection therewith must be done on the ground, and by men familiar with all phases of the problem.

There are, however, many problems which could be turned over to university research laboratories for solution, and these would be valuable for the training of men for the industry. These are problems having to do with such things as methods of measurement, or fundamental laws, such as the laws of heat transferences or the laws of hysteresis.

There should be much closer cooperation between the university and industrial research. Industry should recognize that it must depend primarily upon the universities for its trained research men, and cooperate to the fullest possible extent, to the end that properly trained men may be turned out. Pure scientific research should be recognized as the legitimate field of work of the university. The application of science to industry should be recognized as the field of the industrial research

organization, and it should be realized that no sharp dividing line can be drawn between the two. The university should do research primarily to train men, and the industry to insure dividends to its stockholders.

Governmental differs from industrial research mainly in the fact that it is financed and directed by the Government, and its results should therefore be directly available to all the people. It has many and varied fields, such as those relating to the development and conservation of our resources, the national defense, and the establishment of standards of weights and measures. Much governmental research is undertaken for the benefit of industry in general, and its methods and equipment are necessarily much the same as those used in connection with industrial research. Like industrial research, it must look to the university for the training of its men. As in industry, the present war has brought greatly increased demands on our governmental research departments, and has also shown the desirability of increased cooperation between all the forces having to do with research both at home and abroad. Here, again, it is difficult to draw a sharp dividing line between the work to be undertaken by the Federal or State Governments and that which should be left to industry or to the university. It is safe to say, however, that, as in other lines, research carried on by the Government will increase in amount and in the kinds of work undertaken, and that, further, there will be increased cooperation with other agencies carrying on research.

Industrial research has been described as having for its primary function the securing of dividends to the industry. Fortunately for those engaged in it, its ideals can be just as high as those of pure scientific research, for its work usually results in direct and lasting benefits to mankind. This is certainly true of those researches which have given us commercial wireless telegraphy, transcontinental telephony, half-watt incandescent lamps, giant turbo-generators, modern tool steel, and a host of other things.

In most industries having research departments we can trace their rise from the beginning of the work, even though done under the guise of test work and experimental work, and without any thought of its being research in the sense of the present use of the term. This is particularly true of the specific industry and organization with which the writer is connected.

Full Scale Experimental Work

It is impossible to describe the rise of research in the Westinghouse Electric & Manufacturing Company without giving something of the part taken in it by the great founder of the company, Mr. George Westinghouse. A critical study of his life work will show that he personally carried on research of a high order and in many fields. In his personal work, however, Mr. Westinghouse rarely used ordinary laboratory methods. His experimental work was done on a full-size scale. If he was interested in a rotary engine, he did not build a model; he built an engine to suit the commercial conditions he had in mind. If interested in the development of producer gas, no mere laboratory experiment would suffice; he built a complete producer-gas plant. His work on the development of air brakes, switches and signals, the steam turbine, and many other devices, was all conducted in the same way. He was an experimental rather than an analytical research worker. He undoubtedly had many failures in his experimental work, but the commercial success of the companies which bear his name shows that in the end the balance was greatly in his favor. The foundation of each was largely his own personal work. This type of experimental work, to be successful, requires a breadth of vision, a soundness of judgment, an optimism, and a dynamic energy to carry it forward, which are possessed by but few men. Without these qualities, so abundantly possessed by Mr. Westinghouse, research work done in his characteristic way is more liable to lead to failure than to success. Throughout his active life Mr. Westinghouse always had in hand a number of investigations of the type referred to, and only those who have had the good fortune to work in close contact with him can appreciate the amount of thought, energy and attention to detail which he gave to all of his experimental work. It was characteristic of him that he so drove his work that he would get results in days where the average worker would require weeks or months.

Organization of Research Department

While much research of the kind carried on by Mr. Westinghouse is still necessary in the development of the company's product, it is coordinated with an analytical study of all the data available and supplemented by research in the laboratory, the factory, and the field. The laboratory was early recognized as a necessary part of the engineering equipment, and several were provided for different purposes, in which much research was done. The present organization has resulted from the combining of these laboratories and certain other activities into a division of the engineering department, to which additional facilities for research have been added from time to time. Being a part of the engineering department, and working in close cooperation with the works department, the organization provides for the most intimate possible contact with the problems and requirements of the business and for the most direct applications of the results of research.

The research division is divided into sections, and embraces work from the purely theoretical side of the problems presented to the practical application of principles and materials in the factory and in the field. It has under its control various laboratories, such as an electrical laboratory, a process laboratory, a molded-material laboratory, a materials testing laboratory, a chemical laboratory, a ceramic laboratory, and a more recently acquired research laboratory proper, especially set aside for the work of a more theoretical nature. This latter laboratory has provision for studies in organic chemistry, electrometallurgy, metallography, illumination, general physics, electrochemistry, insulation, etc., etc. The theoretical and the practical research men are in separate sections of the same unit, but work in close harmony. The result of a theoretical research, such as the production of a new device or material, or the application of a new principle, can be tried in a practical way in another section of the division.

The division does all the engineering in connection with the purchase of materials and carries on the experimental work in connection with the establishment of shop processes. The men working on materials' specifications keep in closest possible touch with the method of production of these materials, their characteristics, their engineering application and their shop use. The process men work between the engineering department and the shop, in connection with processes of every sort, and prepare all specifications, with the cooperation of the shop men under which the process is carried out. The division has the technical direction of the brass foundry, the scrap-recovery plant and the copper refin-

ery, and is thus in daily contact with the multitude of metallurgical problems arising in these processes. The control laboratory, as well as the theoretical laboratory, for these processes, being under the direction of the division, the best possible cooperation between the two is insured.

We believe that the research division should both lead and follow the practical end of the work. There should be work going on which has for its object the securing of information or the perfecting of devices which will be required in future years. At the same time, old processes should be improved, old devices should be reviewed, and new treatments should be provided for old material. Research should lead, should follow, and should parallel engineering and factory work.

What of the future of industrial research? What lines will be profitable? Should there be greater centralization and greater cooperation between industrial, governmental and university research? The answers to these questions might well be given with counter-questions. What industrial subject is so far advanced that further advances are impossible? If cooperation is profitable in a single corporation, why should it not be profitable between greater forces? It should be evident from what has gone before that the author believes implicitly in a constantly increasing field for research in every industry. If we can show advances in any material or process or device by proper research, why should not every industry profit by research? It is not expected that every individual study will be profitable nor that every successful result can be at once applied, but careful painstaking and persistent research should benefit any industry. It is expected, of course, that the research undertaken will have a direct bearing on the particular industry and not be a study of some unrelated subject. It would hardly be profitable for the steel industry to make an elaborate study of the life history of the yeast plant, but the progress in alloy steels has so profoundly changed many industries in the last few years that further research in this line will surely be of value.

It is probable that more and more industries will establish research departments or enlarge their research work (often carried on under some other name) and that these will in a large measure for the present work independently of each other. We must expect competition in this line as well as in other industrial lines. We may confidently predict, however, that we will have an increasingly better general cooperation of all research forces. Such agencies as the National Research Council, which bring together for a common purpose men engaged in every phase of research, should have a profound influence on bringing about this cooperation. If such organizations are a benefit in times of national stress and need, surely they can be of similar value in times of peace. The university, the government and industry each has its distinctive field and each needs the cooperation of the others; only when we secure cooperation among all these can we make our best advances as an industrial people.

Industrial Research and the Colleges

By A. E. KENNELLY*

(Non-Member)

IN any general discussion on the influence of research on the development of electrical industries, the share of the colleges in this influence deserves to be defined. The more clearly we can realize the ways in which the colleges can assist in this work, and the more closely we can agree upon the methods by which this assistance can be rendered, the more likely we are to be able to bring about the result desired. In what follows, certain propositions are ventured, in the hope of eliciting discussion, and of thereby reaching a consensus of opinion.

To begin with, it will probably be admitted that industrial research is scientific investigation directed economically toward improvements in production.

It has been known for centuries that discovery and invention have made the fountainhead of new industries. For example, it is said that the starting point of the wealth of Holland—and in the seventeenth century the Dutch republic was the first exporting country in the world—was due to the discovery by the Dutch fishermen, on their remote islands, of a process of preserving fish for storage and transportation. Moreover, throughout all industrial history, men have devoted their time and labor to inventing or designing improved processes in manufacture. Industrial research, in a broad sense of the term, has therefore been at work ever since industry existed. The difference between industrial research in the modern sense, and in the mediæval sense, lies in an emphasis upon applied science, and upon the application of scientific methods. Under the mediæval régime, industry was understood to be handicraft. Individual skill in handicraft was aimed at, through the manual training of apprentices by master workmen. Improvements in production had to come slowly, through the gradual development of skill in successive generations of workmen and apprentices.

The advent of the steam engine and of steam-driven factory machines overthrew, as we all know, the processes of production. These became mechanically stereotyped. The province of individual manual skill changed to the design, direction and management of machinery. The charm of individuality in specially skillful workmanship had to be relinquished in favor of the enormously increased and standardized production of the humanly guided machine. Under the new conditions, mechanical or chemical improvements could be introduced much more easily, partly because of the absence of intellectual inertia in the producing machinery, and partly because of the more definite predetermination and regularization of machine-made over hand-made products.

The introduction of industrial research, in the recent and more restricted sense, has come about partly materially through the opportunity provided by large-scale mechanical or chemical processes, and partly psychologically through the change in the general attitude of mind toward applied science. Formerly there was an attitude

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of distrust toward scientific training in industry. Now it is coming to be realized that in all industry applied science can be made to pay. In fact, it is coming into general apprehension that sooner or later any industry will be outdistanced competitively unless maintained not only by eternal vigilance, but also by eternal scientific study.

The part of the colleges has been and is to train young men to learn a business studiously and to carry it on systematically. In the colonial days, the colleges educated men almost exclusively for the professions. To-day, the men educated in the colleges enter general business in as great numbers as they enter the professions.

In the non-technical scientific departments of the colleges and universities such fundamental subjects as mathematics, physics and chemistry are studied. The duties of these departments of so-called pure-science, that is, science contemplated apart from applications, are twofold:

(1) Teaching, by carrying on instruction of the students in those sciences.

(2) Learning, by carrying on researches in those sciences.

The teaching and the learning have to be carried on interdependently and perpetually.

Development of Pure Science

It is probably undesirable that the pure-science departments of the colleges and universities should continuously undertake industrial research. There is nothing in their work to prevent their teachers or students from undertaking such research. Many on their staffs are excellently qualified for conducting industrial research; but there is so much other important work to be done, which these departments are alone able to do. In all times, the progress of the sciences has been largely left to the college teachers of those sciences. Physics and chemistry are subdivided into so many branches that no one man can do justice by his efforts to more than a small number of studies. There is a limitless field of undreamed-of knowledge everywhere along these lines. The expenses of modern scientific laboratories are so great that few private individuals can expect to conduct researches in pure science, and the instructing staffs in the college laboratories have special facilities for experimental work. The bulk of new scientific material, on which industries may ultimately depend, has to be worked out and discovered in the pure-science laboratories of the world. Again, mathematics is a science covering a range of knowledge, thought and inquiry so vast that no one mind can compass it, and yet its knowledge is woefully backward and deficient, even for purely utilitarian purposes; so that there are immense fields to be developed, even on the unlikely hypothesis that no new general discoveries will be forthcoming. Of the indefinitely great number of mathematical functions that may be mentally reviewed, only a few dozens have yet been tabulated and arranged for practical use. The progress of knowledge in mathematics is far less restricted to the college faculties than the progress of subjects like physics or chemistry; because the necessary plant is so inexpensive—white paper, black pencil and gray matter—yet even here the influence of the college atmosphere for mutual teaching and learning is relatively so productive that a large share of the world's mathematical pioneer work emanates from the colleges.

Under extraordinary circumstances, such as those due to the present World-German war, the pure-science departments may advantageously take up industrial research; as a general rule, however, the best contribution of those departments to industry is by restricting their attention to pure science.

Research in Technical Schools

When we come to the engineering and technical colleges or to corresponding university departments, the opportunities for their sharing in industrial research are greater. In the first place, they train men directly for work in applied science, and, in the second place, their contact with manufacturing industries is greater. By comparison with the pure-science departments, their field of activity is, on the one hand, intellectually narrower; but on the other hand they come into closer relations with the needs and problems of industries. The applied-science college laboratory staffs are frequently occupied on engineering and constructive problems of the industrial world. Such activities are valuable, both to the colleges and to the industries, provided that the amount of industrial research work undertaken does not swamp the regular teaching. The technical colleges can assist in industrial research in the following ways:

(1) Training industrial-research investigators to go out into the industries.

(2) The taking up of particular industrial-research problems by particular members of the laboratory staffs, under individual private agreement with industrial concerns, the work being carried on in the college laboratories.

(3) The same as in (2), but with the work carried on in the workshops of the industrial concerns, instead of in the college laboratories.

(4) By the industries formulating their problems directly to the college as a corporation, and entering into an agreement for the maintenance of research work, in the college laboratories or elsewhere, toward the solution of those problems.

All of the above methods are in vogue, as well as various combinations of them. Each has its particular advantages and disadvantages, in view of the conditions of any individual case. So long as the total amount of industrial research work carried on in a technical college does not exceed a certain amount, depending on the size of its plant, it is not important as to which method is followed. Where, on the contrary, the total demand for such industrial work exceeds that limit, it becomes a serious problem as to how it should be conducted, not only from the standpoint of the college, but also from the standpoints of the industries and of the public.

The only essential difference between scientific researches carried on for an industry, and general scientific researches carried on without reference to any industry, is that the former are expected to bring in results of economic value, and must therefore be safeguarded by secrecy, while the latter, being expected to bring in results of scientific and engineering value only, naturally demand publication so far as they are successful. It is manifest that no industry could afford to undertake research unless it expected the results to pay a profit on the expense, and such profits would be jeopardized if the successful results were communicated to competitors. The watchword of industrial research is therefore loyalty to the industry which makes the venture in investigative effort, and this entails watchful protection as to the secrecy of the investigation and its results.

The large industries install their own experimental laboratories and employ their own experimental investigators. It is natural and proper for them to protect the results of their inventive and experimental efforts, either

by patents or by concealment, as may best suit the industrial need. The colleges can best serve these auto-research concerns by supplying them with well-trained graduates. The difficulties lie in the paths of the smaller industrial concerns, which desire to make progress by scientific effort and systematic study, but which cannot afford the expense of a special private research department. These younger industries must have recourse either to the services of a consulting specialist of the researcher type; or to the services of some specialist college laboratories.

The call of the younger industries on the technical colleges for help is one which the colleges naturally desire to meet, so far as they can do so without disrupting their regular work of teaching and learning. On the other hand, the task is rendered difficult by the need for secrecy, and for the discrimination in dealings which that secrecy may involve. The whole atmosphere of any healthy college is one of intellectual freedom. The ideas and knowledge of any individual in the college community are placed at the academic disposition of all of the rest who may be inquisitively inclined. A recognized exclusive monopoly of information or knowledge must interfere with the best qualities of any institution of learning. Consequently, the maintenance of any considerable amount of industrial research in a college becomes a burden and a difficulty. For this reason, either method (3) or a combination of methods (3) and (4) is perhaps the best for a technical college to follow, when a considerable amount of technical research is desired to be undertaken for those industrial concerns which are not in a position to maintain their own research laboratories.

In the long run, therefore, it seems most desirable that the technical colleges should always carry on general researches in their laboratories of such a nature as may advance applied science, stimulate careful observation on the part of students, contribute to the published fund of available technical information, supply new knowledge to the teaching staffs, and train students for entering industrial research. To this end, research fellowships and research endowments are of the greatest aid both to the colleges and to the industries. A limited amount of industrial research work can also be advantageously carried on in the college laboratories, along with the general research work.

With the growth of new industries, more and more demand for such industrial research comes to the colleges; the desirability increases then of dealing with it in a systematic way, through the college as a corporate body, by maintaining special assistants in the workshops of the industrial concerns under the direction of specialists on the teaching staff. In this way, perhaps, the most effective service may be given by the technical colleges to the junior industries, with the maximum of economy. It may not be too much to expect that as time goes on the junior industries may lean more and more upon the technical help of the colleges, without having to enter into any mututal agreement or combination in order to avail themselves of such aid.

Reference has been made above to the continuous duties of a college, both as to teaching and learning. A third important duty also exists, although its influence on industrial research is less direct, namely, the maintenance and propagation of ideals, or of those underlying habits of thought and action which are sometimes summed up as "character," and at other times are referred to as the working philosophy of life. Colleges foster and transmit such ideals, more or less unconsciously, perhaps, to those who study within their walls, partly by tradition, partly by contact between teachers and pupils, partly by the study of history, philosophy and a host of other horizon-enlarging subjects, and partly by the interchange of student opinions. The transmission of such subconscious motives may not have direct bearing upon the technical attainments of college trained men. Many men who have never gone to college are actuated by ideals as fine as those which any college can claim, nevertheless, the indirect stimulating effect of such ideals on the college-trained researcher is manifest on every hand to the careful observer.

An ideal international system would be one in which the pure-science colleges should lay the foundations of future industries by enlarging and disseminating the world's knowledge of the basic scientific principles, the technical colleges should do the same for applied science, while at the same time taking a share in the economic applications of science to industry. The industries themselves should undertake their own researches, under the guidance of qualified research specialists. Vocational schools would train industrial foremen in the elements of the same principles of science, art, technique, economy, thrift and hard work, as applied to those particular industries in which each nation is, by its peculiar circumstances, specially adapted to excel.

PROPOSED DELIVERY OF MAIL BY AIRPLANES

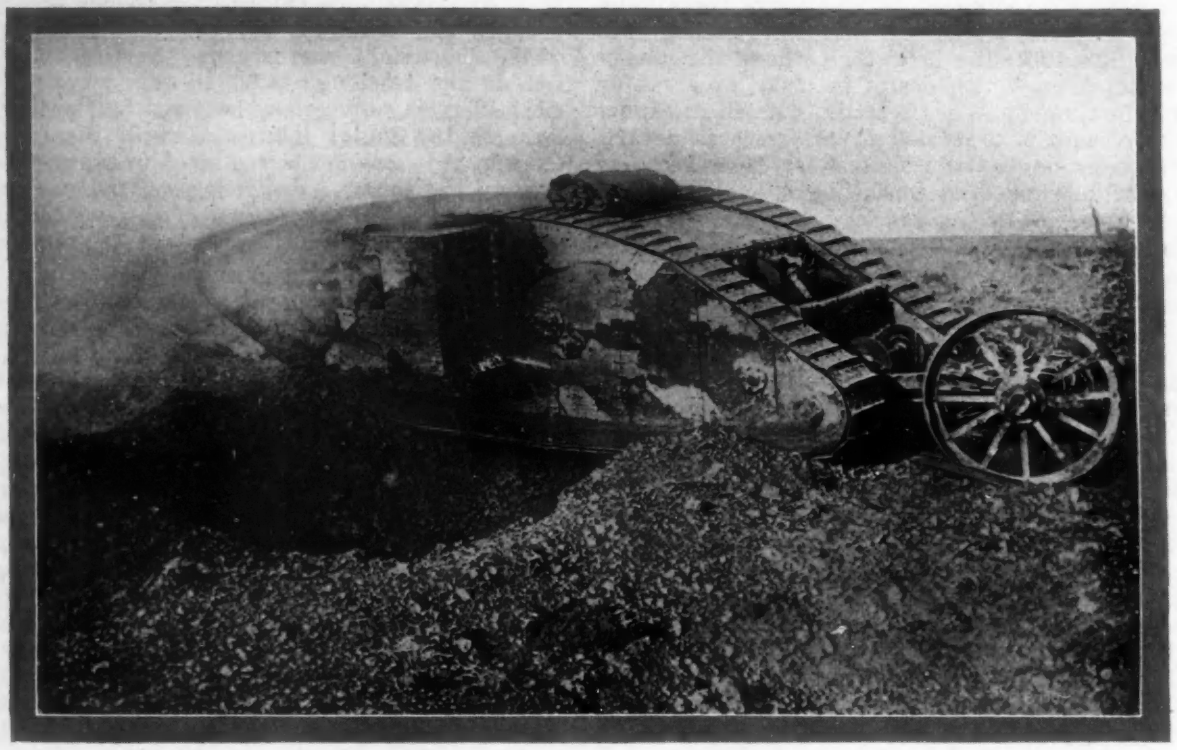
As the result of a conference between Postmaster General Burleson and Secretary of War Baker, and with the approval of the President, Congress is asked to authorize the Secretary of War to turn over to the Post Office Department all military airplanes and motor vehicles not serviceable for military purposes, or which after the war may be dispensed with for military service.

As soon as authority of Congress is secured, and any airplanes are turned over to the Post Office Department, airplane mail routes will be established in the country, as they now are in Italy and France.

Having the approval of the President, the following has been adopted by the House Post Office Committee as an amendment to the Senate bill authorizing experiments in motor-truck delivery by the Post Office Department.

"Provided, That the Secretary of War may, in his discretion, deliver and turn over to the Postmaster General from time to time, and without charge therefor, for use in the postal service, such airplanes and automobiles, or parts thereof, as may prove to be or as shall become unsuitable for the purposes of the War Department, and the Postmaster General is hereby authorized to use the same, in his discretion, in the transportation of the mails, and to pay the necessary expenses thereof out of the appropriation for inland transportation by steamboat or other power boat or by airplanes from the appropriation for inland transportation by star routes."

The bill as amended was favorably reported to the House, and is expected to be adopted speedily.



LATE MODEL OF ENGLISH TANK MOVING OVER SHELL HOLE AT THE FRENCH FRONT

British Workshops and the War

FROM a speech delivered June 28, 1917, in the English House of Commons by the head of the Ministry of Munitions. A most comprehensive account of the wonderful industrial development taking place in England as a result of the war, with a forecast of the plans being made for after-the-war activities.

By DR. CHRISTOPHER ADDISON *Illustrated with* PHOTOGRAPH

IT is a little over two years since a small party of us gathered with Mr. Lloyd George, one Wednesday afternoon, in No. 6 Whitehall Gardens. We were about to open a munitions shop. There was to be one aim and one aim only—to obtain the goods and make delivery of them to the Army. No other interests and no considerations of leisure were to be entertained. A process of man-grabbing was also resolved upon. We were to seek out capable and trustworthy men and to secure their help in the great task on the same terms.

Such was the beginning of a story which I trust that, some day, someone more skilled in the art of narrative than I am will tell in all its romantic interest with faithfulness and with affection. It will be a story of disappointments many, of difficulties manifold and often unexpected, of expedients without end, and of resolute determination by which those difficulties were steadily overcome. It will be a story of improvisations gradually leading up to the formation of an organization which, assuming, or having forced upon it, first this function and then that, became at last as prodigious in its proportions as in its output of munitions. It will be a story of the courage and uncanny insight of Mr. Lloyd George, of the labors of a band of helpers of an unique and splendid character and of the untiring and patriotic efforts of men and women, employers and employed, who by their collective efforts have provided an imperishable tribute to British genius and resource.

* * *

RAILWAY AND MOTOR TRANSPORT

I now come to the group of departments that require the use of steam or internal combustion engines. These are the departments for the supply of railway material, motor transport, tanks, agricultural machinery, and aeroplanes. With the exception of tanks, the responsibility for all these supplies has been added to the Ministry during the past year.

The other day Sir Douglas Haig paid a high tribute to the work of military transportation. It has been the duty of the Ministry to supply the goods, except that the transfer to France of a certain amount of existing railway stock was undertaken by the Railway Executive Committee. There are few more thrilling stories in the history of the Ministry than how Sir Ernest Moir and his colleagues succeeded in a short time in meeting the demand.

The number of locomotives and trucks, with the track

required, was so great that to manufacture all in time—even if there had been the raw material to spare, which there was not—would have been an impossibility. We had therefore to obtain the balance from existing stock where we could. Track was pulled up at home. India, Australia and Canada sent their contributions. The Government of Canada held a meeting, and within forty-eight hours had arranged, if we wanted it, to pull up 800 miles of track and ship it complete. More than 2000 miles of track have already been supplied in a complete condition, and nearly 1000 locomotives of different kinds, apart from hundreds supplied by the Railway Executive Committee.

Motor transport was transferred to us last year, and was at first under the charge of the President of the Board of Trade. It is now directed by Colonel Holden, under the superintendence of Mr. Percy Martin, the Controller of Internal-Combustion Engines. The British Army is well supplied; and we are also able to render much assistance to our Allies in this department.

Agricultural Implement Supply

Agricultural implement supply became one of our duties in the late autumn, and Mr. Edge, who is in charge, has the assistance of a small committee of agricultural implement makers who responded to our request for assistance with the same readiness that has always been accorded whenever we have asked business men to come to our help. Most of the large agricultural implement makers had previously become considerable suppliers of munitions and extensive re-arrangements of work have been rendered necessary in order to meet the large program put forward by the Food Production Department.

Tanks and Airplanes

The tank made his appearance last autumn. I say "his," although we distinguish a male and a female variety. At the close of last year much work required to be done in the way of alteration and improvement, as the experiences of the Somme suggested, but the supplies of the new designs are coming forward excellently. The end of the story is not yet, for the enthusiasm of Colonel Stern, Sir Eustace D'Eyncourt and their colleagues knows no limits.

When early in this year the Ministry of Munitions was asked to undertake the supply of airplanes and seaplanes for the Army and the Navy, it became evident that the mobilization of all our resources for the production of internal combustion engines under a unified scheme of direction was essential. A working relation with the Air Board was established, and the production of all internal combustion engines was placed under the direction of Mr. Martin, who left the B. S. A. Company and the Daimler Motor Company to join the Ministry for this purpose. Formerly there were many shops which were producing a number of different types of engines. By a continued effort to diminish the number of types and to concentrate on the best, with a policy of securing that one shop shall be devoted to the production of only a single type of engine, we have already obtained an enormous increase in production, apart from the addition either of machinery or labor. At the same time, I asked Sir William Weir, who had done such good work for us as Director of Munitions for Scotland, to take charge of the supply of airplanes and seaplanes. He and Mr. Martin became members of the Air Board and of its Technical Committee, not only as representatives of supply, but so as to establish a closer working relation between the manufacturing side under us and the formulation of programs and designs which belongs to the Air Board. Under Sir William Weir's direction, the output of aeroplanes is rapidly increasing. The production for May is more than twice that of December and is four times greater than that of May, 1916. We must not, of course, lose sight of the share in these results which belongs to Sir David Henderson and those who were in charge of the work last year. The supply, however, will become much greater still in a few months' time, for we are working at a vast program of production, and the plans we have in prospect provide for its full realization. There is a pressing demand for skilled workers in this service, and, if they can be obtained, we may be sure of a supremacy in the air in material and equipment as emphatic as it is on land in the case of artillery.

Inland and Overseas Transport

The work involved in connection with the movements of overseas supplies, as well as with the movements of ores, metals, machinery and other munitions in this country, has necessitated the provision of two further sections—one under Mr. Howard Williams for Inland Transport and another under Mr. Burton Chadwick for Overseas Transport.

In overseas supplies alone we are interested in nearly 1,500,000 tons of shipments monthly, and the submarine campaign, bad as it is, will not provide much comfort for our enemies when they know, for example, that of shell components shipped from North America to supplement home production the total loss since the commencement of the unrestricted submarine campaign, taking the heaviest item of loss in any single component, is only 5.9 per cent of the amount shipped.

At the request of the Secretary of State, early in the year Sir Frederick Black and a small number of special officers went to India with a view to assisting the further development of munitions production by placing their experience at the disposal of the Government of India. Sir Frederick Black has now returned, and we are very hopeful that the valuable suggestions he has made will lead to good results.

American and Canadian Supplies

Our supplies from the United States until recently were arranged for, so far as purchase was concerned, through Messrs. Morgans, with separate organizations for supply and inspection. Lately, however, Mr. Gordon, the vice-chairman of the Imperial Munitions Board in Canada, at my request, has moved to the United States, and has been appointed as the head of all our munitions organizations there. Mr. Gordon will report out there to Lord Northcliffe in the same way as the other chief British representatives in charge of shipping, transport, grain purchases, and other services. Some time ago also there was set up in London an inter-Allied Bureau on which our European Allies and ourselves are represented for the purpose of pooling our requirements in the American market as much as possible and for the avoidance of competitive buying. Negotiations are now proceeding at the suggestion of the United States Government for a further consolidation of interest on this side as well as in America. The result of these negotiations, if successful, will be of enormous value not only in enabling the United States Government to place their great resources more readily and effectively at the Allies' disposal, but in promoting economy in purchase. These arrangements have been much facilitated by the work of Mr. Balfour's Mission, on which the Ministry was repre-

sented, among others, by Mr. Layton, the head of the Statistical Department, who also represented us with Lord Milner in Petrograd and with the Prime Minister in Rome.

The Imperial Munitions Board in Canada, under the chairmanship of Sir Joseph Flavelle, is now the greatest business organization in the Dominion. More than 200,000 workpeople are employed by it, and their supplies, which cover almost the whole field of munitions, are dealt with on this side by the Hon. R. H. Brand, who was at one time a member of this House.

Increased Output of Steel

Overseas supplies bring me to that group of departments which is concerned with the supply, distribution, working up and control of the various necessary minerals and metals. Do what we will to avoid fresh burdens, the work of this group of departments continues to grow from day to day, but there is nothing of more hopeful augury for the future than the proofs which we are thereby accumulating of the great undeveloped potentialities of our Home and Colonial resources.

Before the war, the output of steel in this country had been more or less stationary for some time—at a little over 7,000,000 tons per annum. The output is now nearly 10,000,000 tons and I shall be very much disappointed if, with the schemes which are now being worked at, we have not reached the rate of a 12,000,000-ton output by the end of next year. We shall then have gone far toward doubling the pre-war steel output of this country and I do not need to emphasize all that is involved in this addition to our industrial strength and resources.

With the exception of the rich deposits in Cumberland, nearly all the iron-ore mined in this country is of a somewhat low grade and is of the basic variety as distinguished from the acid or hematite ores of Cumberland and those which form so large a proportion of our imports. As a result of our great imports of hematite ores, many of the blast-furnaces and steel furnaces of the country have been specially adapted for its use and a more extensive use of home-produced basic ores involves important modifications in working plant. In order to make ourselves as safe as possible against the worst the submarines could do, I asked Mr. John Hunter, under whose strong leadership the whole of the steel department works, to have a comprehensive survey made as quickly as possible, with a view to making the utmost use of home ores in case the submarine menace proved effective in restricting importation. We do not aim at restricting importation, but we aim at increasing our steel supplies—and increasing them as rapidly as possible—by the use of home ores. Mr. Hunter got together a strong band of willing experts, the program was rapidly formulated and the Government decided to use every endeavor to give full effect to it. The increased production of basic steel from home ores, with the consequent adaptation of old or the bringing in of new furnaces, should provide us with the capacity for the production in this country by the spring of next year of an additional one and three-quarter million tons of basic steel above our previous home production. Added to this, we propose an extended use of the hematite ore from Cumberland for the production of acid steel, provided the necessary labor can be obtained. I cannot pretend to give in this short summary any adequate impression of the enormous amount of detailed labor which the preparation and working out of this scheme has involved and of the laborious days which have been spent in its elaboration by the gentlemen who have placed their services at our disposal; suffice it to say that, within about fourteen months from the commencement of the scheme, we shall have increased our home capacity for the manufacture of basic steel by 30 per cent. The demands for steel are so many that we have had to make our control of this precious metal very close indeed, and I must acknowledge the loyal acquiescence of the great body of steel users in accepting the restricted allocations which the Ministry have been obliged to make. The demands, however, upon our steel-producing capacity are so great that, with all the help which we derive from Canada and the United States, I cannot, in fairness, offer any immediate prospect of relief.

A signal success with respect to the fixing of prices has been achieved in this branch of supply. Nothwithstanding the costs of material and labor, we are obtaining steel plates in this country at less than half their cost in the United States, where shell steel also costs 30 per cent more than it does at home.

Profitable Enterprises in Non-Ferrous Metals

The Non-Ferrous Metals Department is under the charge of Mr. Leonard Llewelyn, and is responsible for our supplies of spelter, aluminum, copper, tungsten, brass, antimony, lead, nickel and other metals. The production in this country before the war of spelter or commercial zinc was only about one-third of our national requirements. Before the end of the present twelve months I hope that the country will have double that capacity, and I believe that the new works will be found not only designed on the most modern lines, but capable commercially of holding their own with any spelter plants in the world. A part of the scheme involves the working up of the Australian zinc concentrates, which were formerly largely under German control, and we have in hand some schemes for increasing the output of refined spelter, both at home and in Canada.

Some time ago steps were taken to obtain control of the wolfram ores in the Empire with a view to regulating the stocks of tungsten which are necessary for the production of high-speed steel, and if anyone cares to compare the price of the high-speed steel that we are obtaining in Sheffield with the price in New York, I think he will be satisfied that the country has enormously profited by these enterprises.

Works have been established at home for the production of tungsten which enable us fully to meet our own requirements and to supply much besides to our Allies.

By a system of rationing of aluminum supplies we have converted a deficit into a surplus. At the same time, steps are in hand which will increase the home production of aluminum by 45 per cent as compared with pre-war days. The control of copper has been one of special difficulty and complexity. The arrangements made have certainly enabled us to avoid in a great measure some of the penalties of the very high prices which have prevailed, but there are few important metals of which there is greater need for scientific and methodical development in this country than is the case with copper.

Development of Mineral Resources

So much impressed have we become with the importance of rendering this country in the present emergency as independent as possible of foreign supplies of minerals that a short time ago we invited a small committee of engineers and mining experts, under the chairmanship of Sir Lionel Phillips, to collect information and to make proposals, under a unified scheme, for the development for war purposes on commercial lines of the min-

eral resources of the United Kingdom. Much useful information has already been collected, and we anticipate very valuable results from the work of this committee.

Owing to the insufficiency of the world's supplies of certain metals for munitions and for all commercial purposes, we have had to establish an elaborate system of priority certificates, and some little time ago, at the suggestion of Mr. Edgar Jones, M.P., the Controller of this Department, after a conference with our colonial representatives, arrangements were made for the colonies and India to cooperate in the examination of their demands upon us on lines similar to those we have adopted at home. The Priority Department has to adjudicate on an average upon more than 9500 applications per week. It has about 1000 individual interviews with representatives of firms every week, and its control extends over steel, iron, copper, lead and other metals, as well as over numerous alloys.

Some time ago, in order to be as secure as we could that this work was carried out with a minimum of hardship to private trade, I instituted a standing priority committee of business men, under the chairmanship of Mr. John Wormald, of Messrs. Mather and Platt, to examine and advise upon various schemes of priority as they affected individual industries. The trades that have been examined cover a large variety of industries, from the manufacture of washing machines to that of jewelry.

Scrap Collecting and Salvage

Priority is one method of effecting economy in the use of metals. Further help has been given by the institution of a system of scrap collecting and distribution. This is now getting into working order throughout the country under the direction of Mr. Alexander Walker, and it should lead to an extensive cleaning up of the masses of scrap of all kinds which may still be seen in some places and in various munition works.

With a view also to rendering further assistance in this direction, we have established an extensive Salvage Department, under Sir Charles Ellis, which works in cooperation with the armies at the front for the salvage, re-shipping to this country, re-forming and re-issue of a large number of parts of munitions. We are now able to re-form hundreds of thousands of 18-pounder cartridge cases. When it is remembered that the price of a new case is about 7s., that it can be re-formed four times, and that we are re-forming cases at the cost of 4d. a case, the importance of this branch of work is obvious.

As another contribution toward the saving of metals, an expert committee, presided over by Mr. Fielding of the Rio Tinto Corporation, and working in conjunction with the Designs Department, is now charged with the duty of making recommendation for economizing the use of the more expensive metals. Largely through the efforts of this committee we are securing a reduction in the amount of copper used in copper-bands, amounting to a saving of many thousands of tons of copper in a year; and less expensive metals are now being brought into use as constituents of various fuses and other shell components.

New Inventions

Many useful suggestions in the direction of economy and for the utilization of cheaper materials have been received from the Munitions Inventions Department under Colonel Goold-Adams. There is still a steady stream of suggestions and more than 6000 have been reported on since the beginning of the present year. Many valuable contributions have been made over a wide field, varying from improvements in scientific instruments and modifications in defensive and offensive apparatus to economies in the use and treatment of fuel. In sixty-five cases special rewards have been made to employees of firms for useful suggestions.

And here I should like to make a passing reference to the fact that attempts are being made to promote the production of nitrates at home with the avoidance of importation, in accordance with proposals founded upon the work of the Nitrogen Products Committee—a committee which consists of a number of eminent engineers, manufacturers and scientific men, under the chairmanship of Colonel Goold-Adams.

Special efforts are also being made in these islands for the development of oil production. Thanks largely to the tact and knowledge of Professor Cadman, we have already promoted an excellent working arrangement between the workpeople and employers in the Scottish shale districts, which has resulted in a great economy in the methods of production, as well as in an increased output of oil. Subjects such as these have necessarily led us to appeal for the aid of a large number of scientific men, especially chemists, physicists and engineers, and we have not appealed in vain.

Superiority in Trench Warfare

The Trench Warfare Research Committee, under the chairmanship of General Jackson, has been responsible for the initiation and development of the more highly specialized forms of warfare which are peculiar to the trench fighting on the Western front. I cannot, of course, describe in detail any of the new developments, but I can say, with confidence, that although we started behind in the race, we are probably now as superior to the Germans in this section of warfare as we are in that of artillery.

The Trench Warfare Supply Department, under Sir Alexander Roger, covers an enormous variety of supplies from fireworks and grenades to the heaviest form of bombs, also helmets, shields, specialized chemical apparatus, trench mortars and their ammunition. This department has supplied one and a half-million steel helmets during the past six months. As an illustration of the increasing demands of the Army for trench warfare material, I find that in December the tonnage requirements amounted to 7648 tons, while last month it reached 17,963 tons.

* * *

The Problems of Reconstruction

From what I have said it will be recognized that the problems of reconstruction, and the possibilities of useful developments which the experiences of the Ministry have provided during the last two years, are so many and of such great moment that they may well engage the constant attention of the best minds. While, with true British instinct, we dwell upon our faults and failings, nothing throughout the war has been of greater value than the proof which has been afforded that, given the incentive and the intention, the nation is abundantly equal to making a full use of the lessons and of the opportunities that present themselves.

Nothing in the relations between capital and labor gives rise more to difficulty and distrust than two customs which are dependent upon one another. The first is the cutting of rates of pay on piece work so as to limit the rise of earnings when improved methods of

manufacture, leading to a great output, are introduced. It is not the practice of the best employers, but it is adopted by many. This practice—or the fear of it—has inevitably led to the second and retaliatory practice of the restriction of output. The influence of these two practices in our industrial life is thoroughly poisonous. We must establish a system whereby both parties have a direct interest in the introduction of improved methods. Without it our progress will inevitably be accompanied by endless disputes. The accounting side of the Ministry has abundantly proved that modern methods of production are not only well able to afford good wage rates, but are benefited by so doing.

Redeeming Neglected Opportunities

In some industries, vital to the prosecution of the war and to the maintenance of improved peace industries, we had allowed the Germans to acquire control, either of the whole industry or of some part of it which was essential to its continuance. We have steadily overcome these drawbacks, but it is almost impossible to describe the handicap they have been. In overcoming them, however, we have been awakened to some of our neglected opportunities and have founded—and will be able to found with proper direction—great new industries and extensions on a vastly improved scale of old ones. Should the war last, we ought to find ourselves next year with a capacity for steel production more than 50 per cent greater than it was before the war, with modern coke ovens, equipped with recovery plants, with knowledge of how to extract and use the valuable by-products, with groups of blast-furnaces, steel furnaces and rolling mills arranged on a big scale, suitably situated and coordinated with one another. Instead of being able to produce at home about one-third of the spelter that national industries require, we should have a capacity for producing two-thirds or more. Instead of having to look to Germany for our fertilizers, we should be able to produce at home spelter and acid and fertilizers and many other products related to these trades by modern, economical, and efficient methods on a vastly augmented scale.

At the beginning of the war we found ourselves with no facilities to smelt the copper produced in our own colonies. We were dependent upon Germany for the potash so vital to some of our industries and to our agriculture. The story of glass and dyes is so well known that I need do no more than refer to it, and the catalog could be continued to a great extent. There are, however, two matters of great moment to which I should like specially to allude. We have had to import nitrate from Chili and pyrites from Spain, for practically every ton of essential nitrates that we require. I have good hope of the schemes which are at present in hand for the use of gas-works ammonia and for the production of cyanamide, as well as otherwise for obtaining nitrogen. Germany is obtaining all her nitrates without a cargo from Chili. The importance of the solution of this problem as a key to immense industries can scarcely be exaggerated, and no effort should be spared to solve it on commercial lines.

The other problem of equal magnitude and, in some respects, closely related, is the provision of cheap power and the utilization of inferior coals. I cannot go into details, but important developments are in progress, and it is most important that no effort should be spared to bring them to a successful issue.

We have suffered in the war not only from old-fashioned plant and negligent financial methods but from a serious neglect of research and scientific work as applied to industry, and I should like to acknowledge the help which has been afforded by the committee on Scientific and Industrial Research, in the origin of which I may perhaps claim some parental pride. Our manufacturers are awakening to this need, and so is labor, and I cannot think of any national investment worthier of thought and of cost than this one.

A number of the chief men of the different departments of the Ministry are at work on plans for reconstruction, and there is a Ministry Reconstruction Committee to secure uniformity of direction in accordance with an arrangement made with the Central Reconstruction Committee. The destination of our national factories will at once suggest itself as an important matter for consideration, but others are emerging which may be of greater consequence even than this.

The flow of demands in the priority department points to an opportunity of securing a great volume of useful commercial work for this country. The flow of foreign orders, demands for restoration abroad, the needs of our railways and shipyards and common service undertakings show that there are abundant opportunities before us. If preparations are made beforehand, it should be possible, by a wise administration, to help in bridging over the transition between the disestablishment of the industries of war, and the establishment of those of peace. At the direction of the Imperial War Cabinet the Ministry is taking steps which will assist in providing information on commercial lines as to the mineral resources of the Empire. We want information which will be available not simply in general terms, but examined and proved, so that we may be able to know not only what resources there are, but by what methods and at what cost they may best be developed. There are mineral resources at home, which have been scarcely tapped, and what applies to these small islands applies with much greater force to the almost infinite resources of the British Empire.

The Forward Look

These things are worthy of the sustained attention of the best minds the nation can command, and we should consider them not from any narrow profiteering standpoint, but in such a way as will enlist the help and sympathy of all classes.

As we review them and reflect upon all the possibilities of development, both in material and in human things which they disclose, we gather, amidst our labors, further resolution, and take fresh courage in our determination to endure until, in company with those who are fighting with us, we have put down military tyranny in the world and have thus removed the one great obstacle in the way of real human advancement.

The minds of men are open, all hearts are stirred, and the power and capacity of our people is proved to be so great and so sufficient that, properly directed, patiently, with consideration and with careful forethought, the end is sure.

We look forward, therefore, to the future with a confidence made strong by the experiences and work of this great Department, the record of whose achievement is to be found, not in this incident or in that, not merely in great industrial advances at home, but in far distant lands, at the gates of Gaza, on the hills of the Carso, on the stricken fields of France and Belgium, wherever the British Army is to be found—an Army which in its equipment of munitions is now equal if not superior to any other army in the world.

Current Standardization Work

THE most important activity of the month was the Aeronautic Standards Convention held Sept. 29 and Oct. 1 at Washington. A general account of the convention is given on page 227 of this issue. The reports presented on aeronautic subjects are given below. It is expected that they will be acted upon at a meeting of the Aeronautic Division, to be held Oct. 28 and 29 at the Bureau of Standards. Appended are also outlines of the work done at recent meetings of the Lighting, Marine, Motorcycle and Tractor Divisions.

The Data Sheet Division is devoting its time to the application of an indexing system to the data sheets. This has become necessary through the growth of the book in the last few months, the present system failing to meet the requirements for a quick and comprehensive index. At the present stage of the Division's work a modification of the Dewey Decimal System is receiving favorable consideration. The contemplated system will permit a comprehensive index and general expansion of the S. A. E. handbook.

The Lighting Division will meet Nov. 1 in Detroit.

The Miscellaneous Division held a meeting on Oct. 5 in Chicago, but no formal report was made. Mr. Ehrman is working on the steering-wheel screw-thread situation with the intention of obtaining a thread that will answer all the existing conditions.

The next meeting of the Tractor Division will be held Dec. 4 in Minneapolis. The new quarters of the Minneapolis Section of the S. A. E. will be used for the first time at this meeting.

Aeronautic Division Meeting

The following reports on dope, engine testing, engine weights, glue and tension members, round and streamline wires were given by committees of the Aeronautic Division at the Washington meeting.

Report of Dope Committee

The members of the dope committee present were: W. H. Smith, chairman; F. O. Aspinwall, L. H. Austen, Jasper E. Crane, F. Doerflinger, E. L. Georger, J. B. Johnson, J. J. Moosmann, H. S. Mork, M. R. Ridell and J. H. Waterbury.

The committee recommended that two coats of acetate dope be substituted for spar varnish on training machines. The temperature of the doping rooms of airplane factories should be maintained at 70 deg. fahr. and the airplane manufacturers should store the dope under cover. Specifications which were proposed by the committee follow:

Cellulose Acetate Dopes

Definition.—Dopes for airplane fabrics must consist of a clear, uniform mixture of ingredients and be capable of shrinking the fabric to the degree of tautness desired by the Signal Corps inspection. The residual film should be reasonably transparent and free from white spots, and should give a smooth, homogeneous surface when applied in a horizontal position in an atmosphere not exceeding 65 per cent humidity and 75 deg. fahr. temperature and free from direct draft.

Viscosity.—The viscosity of the dope must permit direct application without dilution at a temperature not lower than 60 deg. fahr.

Coating.—The dope, when dry, must adhere to the fabric with sufficient tenacity to prevent peeling off in sheets. Test strips should show lint attached to the side which has been in contact with the fabric.

Effect on Tensile Strength and Weight.—Four coats, or an equivalent of dope, must, forty-eight hours after application, increase the tensile strength of linen fabrics not less than 25 per cent of the original strength, and of cotton fabrics not less than 15 per cent. The increase in weight per square yard of doped fabric should not be less than 2 ounces nor greater than 3.5 ounces. The test shall be made under standard conditions of humidity and temperature, on standard fabrics.

Acidity.—No mineral acids may be present in the dope and the amount of free organic acidity figured as acetic acid may not exceed 0.2 per cent. No compounds may be present which would be injurious to the fabric.

Sulphates.—Dopes which show the presence of free sulphuric acid by the test given below are not acceptable.

Tetrachlorethane.—Dopes containing tetrachlorethane are not acceptable.

Cellulose Acetate.—The cellulose acetate used should contain no free mineral acid and not more than 0.1 per cent of free acetic acid, and should be stable. The amount of cellulose acetate shall be not less than 60 grams per liter of dope.

Solvents.—The volatile solvents employed should present no danger to the workmen applying them.

Inflammability.—Five drops of gasoline dropped on the film which has been dried for forty-eight hours and immediately ignited, should have no more serious effect than to char the fabric under the moistened section of the film.

Exposure Test.—Dopes must comply with the following test: A square 12-inch frame, inside measurement, is covered on both sides with fabric, the fabric being tacked to the outer side of the frame under uniform tension, simulating the conditions employed in airplane manufacture. Four coats, or an equivalent, of dope, are to be applied to each side of the frame, each coat being allowed to dry thoroughly before the succeeding coat is applied. The frames are to be exposed on a roof in an unshaded horizontal position, one side being constantly uppermost. After sixty days of constant exposure no spontaneous cracking of the doped surface should be apparent, and after remaining one hour at a temperature of 70 deg. to 80 deg. fahr., the film shall not crack and shall have a decided ring. This test shall be made comparatively with a dope that has previously passed the test, and shall be in effect until a mechanical test is adopted.

Shipment.—Dope shall be shipped in metal cans, metal or wooden barrels or earthenware containers. Inspection of the containers shall be permitted to insure against the accidental introduction of foreign material. The container shall be marked with the date of manufacture, serial number, gross, tare and net weight.

Testing of Dope

Acidity.—A 500 c.c. beaker, containing about 200 c.c. of water, is counterbalanced on a large balance which is adjusted to 0.01 gram by adding or removing water.

About ten grams of dope are poured into the water and the increase in weight noted. This is rapidly done to 0.01 gram to diminish the solvent loss. The dope is stirred up and allowed to stand 10 to 15 minutes with occasional stirring. The liquid is decanted through a rather porous filter into an 800 c.c. beaker, and 150 c.c. of warm water added to the residue. It is allowed to stand 10 to 15 minutes with frequent stirring and poured through the filter into the 800 c.c. beaker. The residue is washed with 150 c.c. of warm water as before. A few drops of phenolphthalein are added and the solution titrated with tenth-normal caustic soda to a color that persists for one-half minute.

Some dopes, notably those containing much acetone, when poured into water precipitate as a milky solution containing shreds of the acetate. The resulting liquor filters slowly and passes through the filter paper in a cloudy condition. Since the acetate is finely divided, it is practically free from acetic acid and additional washing is unnecessary. The end-point is not quite as sharp as when all the acetate has been removed, owing to hydrolysis of the suspended material, but is sufficiently accurate for all practical purposes. Absence of mineral acids must be proved by qualitative tests.

Sulphates.—Twenty grams of cellulose acetate dope are treated with 150 c.c. of water in a pressure bottle at 100 deg. for twenty-four hours. The resulting liquor is filtered and tested for free sulphuric acid.

Amount of Cellulose Acetate.—Pour 25 grams of the dope into a Petri dish 6 inches in diameter, and evaporate to dryness on a steam bath. Extract the residue with ether in a soxhlet until all extractive material has been removed. Dry at 60 deg. to constant weight and weigh.

Film.—Pour some of the dope on a glass plate and allow to dry spontaneously. The film may be examined for the general characteristics of transparency, coherence, strength and flexibility.

CELLULOSE NITRATE DOPES

Definition.—Dopes for airplane fabrics must consist of a clear, uniform mixture of ingredients and be capable of shrinking the fabric to the degree of tautness desired by the Signal Corps inspection. The residual film should be reasonably transparent, and free from white spots, and should give a smooth, homogeneous surface, when applied in a horizontal position in an atmosphere not exceeding 65 per cent of humidity and 75 deg. fahr. temperature, free from direct draft.

Viscosity.—The viscosity of the dope must permit of direct application without dilution at a temperature not lower than 60 deg. fahr.

Coating.—The dope, when dry, must adhere to the fabric with sufficient tenacity to prevent peeling off in sheets. Test strips should show lint attached to the side which has been in contact with the fabric.

Effect on Tensile Strength and Weight.—Four coats, or an equivalent, of dope must, forty-eight hours after application, increase the tensile strength of linen fabrics not less than 25 per cent of the original strength, and of cotton fabrics not less than 15 per cent. The increase in weight per square yard of doped fabric should not be less than 2 ounces and not greater than 3.5 ounces. The test shall be made under standard conditions of humidity and temperature on standard fabrics.

Acidity.—No mineral acids may be present in the dope and the amount of free organic acidity figured as acetic acid may not exceed 0.2 per cent. No compounds may be present which would be injurious to the fabric.

Cellulose Nitrate.—The cellulose nitrate used in the manufacture of dope shall be purified and give a negative potassium-iodide test at the end of twenty minutes, according to the standard method. The amount of cellulose nitrate used shall be not less than 55 grams per liter of dope.

Solvents.—The volatile solvents employed should present no danger to the workmen applying them.

Exposure Test.—Dopes must comply with the following test. A square 12-inch frame, inside measurement, is covered on both sides with fabric, the fabric being tacked to the outer side of the frame under uniform tension, simulating the conditions employed in airplane manufacture. Four coats, or an equivalent, of dope are to be applied to each side of the frame, each coat being allowed to dry thoroughly before the succeeding coat is applied. The frames are to be exposed on a roof in an unshaded horizontal position, one side being constantly uppermost. After sixty days of constant exposure no spontaneous cracking of the doped surface should be apparent, and after remaining one hour at a temperature of 70 deg. to 80 deg. fahr., the film shall not crack and shall have a decided ring. This test shall be made comparatively with a dope that has previously passed the test, and shall be in effect until a mechanical test is adopted.

Shipment.—Dope shall be shipped in metal cans, metal or wooden barrels or earthenware containers. Inspection of the containers shall be permitted to insure against the accidental introduction of foreign material. The container shall be marked with the date of manufacture, serial number, gross, tare and net weight.

TESTING THE DOPES

Acidity.—A 500 c.c. beaker, containing about 200 c.c. of water, is counterbalanced on a large balance, which is adjusted to 0.01 gram by adding or removing water. About 10 grams of dope are poured into the water and the increase in weight noted. This is rapidly done to 0.01 gram to diminish the solvent loss. The dope is stirred up and allowed to stand ten to fifteen minutes with occasional stirring. The liquid is decanted through a rather porous filter into an 800 c.c. beaker, and 150 c.c. of warm water added to the residue. It is allowed to stand ten to fifteen minutes with frequent stirring and poured through the filter into the 800 c.c. beaker. The residue is washed with 150 c.c. of warm water as before. A few drops of phenolphthalein are added and the solution titrated with tenth-normal caustic soda to a color that persists for one-half minute. Any satisfactory substitute method will be permissible on approval.

Amount of Cellulose Nitrate.—Pour 25 grams of the dope into 100 grams of chloroform, stirring constantly. Extract in a soxhlet with chloroform until all extractive material has been removed. Dry at 60 deg. cent. to constant weight, and weigh.

Film.—Pour some of the dope on a glass plate and allow to dry spontaneously. The film may be examined for the general characteristics of transparency, coherence, strength and flexibility.

REPORT OF ENGINE TESTING COMMITTEE

The following factory and type tests were recommended by the engine testing committee composed of Major E. J. Hall, chairman; H. E. Morton, acting chairman; Major J. G. Vincent, J. R. Cautley for H. M. Crane, Lieut. Com. A. K. Atkins, F. S. Duesenberg and C. B. King.

ROUTINE FACTORY TEST FOR FIXED ENGINES

Test No. 1.—Engines may be run in by such methods as are found most satisfactory for each type of engine, but must not be run under own power over ten hours before the first official test.

Low or Normal Compression

Test No. 2.—For engines with a compression ratio of 5 and below the engine will be mounted on a torque stand or stationary stand and fitted with club or propeller, properly calibrated for rated load at rated speed. Engine will be fitted with all the accessories that are to be supplied by the engine manufacturer. If started by hand, it must in every attempt be started by one man within five minutes.

Test will consist of: Four hours continuous running at rated power and rated speed. All readings required shall be recorded every ten minutes on S. A. E. standard log sheets.

a. The test must be continuous and in case of a stop occurring during the first hour, the run will be repeated.

b. In case of a stop occurring after the first hour and not due to a fault of the engine, the run will be continued, but the inspector may require an extension of the running time equal to twice the time lost. When a stop occurs at any time owing to a fault of the engine, the inspector may require the complete run to be repeated.

c. No manipulation of the engine, while running, will be allowed, except such as can be made from the seat by the pilot. Replenishing of gasoline and oil supplies and regulating of the cooling-water temperature is allowable. Engine will be disassembled, inspected and if all parts are accepted, it will be reassembled. If in the opinion of the inspector, parts must be replaced, he may require the whole or portion of the run to be repeated.

Test No. 3.—Engine with all the accessories that are to be supplied by the manufacturer will be mounted on a torque stand and fitted with a club or propeller, properly calibrated. It will be given a continuous run of one hour at not less than rated power and rated speed. All readings required will be recorded on S. A. E. standard log sheet every ten minutes. After this test the engine shall be cleaned and inspected and put into condition for shipment. If satisfactory, the engine shall be stamped by the inspector.

Note:—If desired, the horsepower may be corrected for air temperature and barometric pressure. In such cases the power will be corrected to a surrounding air temperature of 59 deg. fahr. (16 deg. cent.) and normal sea-level pressure which is 39.92 (760 mm.) in. of mercury at 32 deg. fahr. (0 deg. cent.) and at 45 deg. latitude. In case of question, the corrected power shall govern.

High Compression

Test No. 2*A*.—For engines with a compression ratio exceeding 5 the engine will be prepared as under tests No. 1 and No. 2. This test will consist of four hours' continuous running at 8/10 rated load and rated speed. Otherwise, this test will be the same as No. 2 and the same rules will apply. Disassembly and inspection will be the same as between tests No. 2 and 3.

Test No. 3*A*.—This test will be the same as No. 3 but at 8/10 rated load and at rated speed. After this test, the engine will be inspected and accepted as in routine test No. 3.

TYPE TESTS FOR FIXED ENGINES

The first engine of a type and one out of each hundred in production will be given the following test. The selection of this engine shall be made by the inspector without previous notice to the manufacturer. The engine must not run under its own power over ten hours before the first official test and must be taken from regular production. (See No. 1 routine test.)

Low or Normal Compression

Test No. 4.—For engines with a compression ratio of 5 and below the engine is to be mounted and equipped as in Test No. 2 of routine tests and fitted with a club or propeller properly calibrated.

Total running time shall be fifty hours divided as follows:

Five hours at 9/10 rated power and at rated speed with not over one hour stop with minor adjustments allowed.

Five hours at 9/10 rated power and at rated speed with not over thirteen hours stop, during which engine may be disassembled, overhauled, carbon removed, valves ground and adjusted, magnetos and spark-plugs cleaned and adjusted. No adjustment or replacement of major parts is allowed. Any multiple part, such as a valve, may be replaced when replacement is made necessary through defective material. In no case, however, shall more than one such part be replaced during the entire fifty hours.

Five hours at 9/10 rated power and at rated speed with not over one hour stop with minor adjustments allowed.

Five hours at 9/10 rated power and at rated speed with not over thirteen hours stop and same work allowed as before.

Five hours at 9/10 rated power and at rated speed with not over one hour stop with minor adjustments allowed.

Five hours at rated speed and at rated power with not over thirteen hours stop and same work allowed.

Five hours at rated power and at rated speed with not over one hour stop with minor adjustments.

Five hours at rated power and at rated speed with not over thirteen hours stop and same work allowed.

Ten hours at rated power and at rated speed.

Rule *c* under routine test No. 2 will apply to each run.

In case of a forced stop during any of above runs, rules *a* and *b* under routine test No. 2 will apply.

If the stop is owing to a failure of any multiple part such as a valve, the part may be replaced, providing such failure is owing to defective material and a similar part has not previously been replaced since the fifty-hour test was started.

During complete run all required readings must be recorded on S. A. E. standard log sheet every ten minutes. The mean power (see note under routine test No. 3) must not fall below the rated power; and gasoline and oil consumption must not exceed the predetermined maximum.

After the test is completed, the engine is to be disassembled and if acceptable to the inspector, may be reassembled after replacing any parts which the inspector may designate.

High Compression

The same rules apply regarding preparation and selection as for Test No. 4.

Test No. 5.—Engine is to be mounted in a body or tilting stand and fitted with propeller. With the axis of the engine making 15 deg. with the horizontal, it is to run at full power full speed for fifteen minutes. Then without altering speed or any part, or adjustment, the axis is to be brought again horizontal and then tilted to

15 deg. in the opposite direction and run fifteen minutes. If this test is satisfactory, the engine will be put through routine test No. 3 except that the running time shall be thirty minutes instead of one hour. After this test, the engine will be inspected and accepted as in routine test No. 3.

Test No. 5A.—Engine will be put through a test the same as No. 5 but at 8/10 rated load and at rated speed. If the engine passes Test No. 5A it will be put through routine test No. 3A except that the running time will be thirty minutes instead of one hour. This engine will then be inspected and accepted as in routine test No. 3.

Test No. 6.—For engines with a compression ratio exceeding 5 this test will be the same as test No. 4 but the first five runs shall be made at 7/10 rated load and at rated speed. The next four runs will be made at 8/10 rated load and at rated speed. Disassembly and inspection will be the same as between tests No. 4 and No. 5.

REPORT OF GLUE COMMITTEE

The committee on glue, J. B. Johnson chairman, and F. W. Caldwell, recommended the following glue specification for consideration:

Process Specifications

I. Tests at airplane factory are made to determine the strength of the glue joints under the average conditions prevailing in the glue room. Tests shall be made on representative woods used by the manufacturer concerned. The glue test specimen shall be made of three boards ¾ to 1 in. thick, 4 ft. long and 5½ in. wide. The gluing must represent actual practice, and no special precautions other than those ordinarily used shall be taken in preparing the glue or wood for the test specimen. The gluing shall be performed by the employees of the airplane factory who are accustomed to handling this kind of work. No protective coating of any kind shall be applied to the wood surfaces or to the finished specimen. The specimen shall set not longer than one week. The 4-foot specimen shall be cut lengthwise and ten shear blocks cut from each half, according to the dimensions given. The shear blocks shall be tested as follows:

(a) Ten of the shear blocks shall be tested immediately after sawing. The strength of the glue in shear shall not be less than that of the wood.

(b) Ten of the shear blocks shall be soaked in water at 20 deg. cent. for fifteen hours, and tested within thirty minutes after removal from the water, without any preliminary drying. The strength after soaking shall not decrease more than 60 per cent.

The required strength shall be obtained for 80 per cent of the samples tested under each condition. A rejected propeller may be substituted for 4-foot specimen specified above.

II. The tests at the airplane factory shall be in the presence of an inspector for the Signal Corps regularly stationed at the factory and familiar with the methods employed there. A test shall be made whenever a brand of glue is changed or a change is made in the method of gluing which in the opinion of the purchaser's inspector is important enough to warrant a test.

Material Specifications

General. This specification covers all glue for propeller construction and for splices of important structural members, such as longerons and beams. For all other work where woods of low shearing strength are used, any glue recommended by a reputable glue manufacturer can be used.

Quality. The glue must be a high-grade hide glue, sweet, and free from any deleterious substances. The glue shall be compared to a standard sample for adhesiveness, jelly strength, viscosity, grease and foam. The standard sample may be obtained from the Director, Forest Products Laboratory, Madison, Wis.

Tests for Adhesiveness. The glue manufacturer may compare his glue with the standard sample by any methods he desires. The tests by the Government, however, will be made as follows:

The strength test will be made by gluing together two pieces of maple or birch 1 in. thick, having a shearing strength of at least 2400 lb. per sq. in. This will require wood having an air-dry weight of about 50 lb. or more per cu. ft., and a moisture content of from 8 to 12 per cent. These will be tested by shearing them in a testing machine. The glue will be mixed in proportions of 2 parts of water to 1 part of glue, unless otherwise recommended by the glue manufacturer. It will then be melted in a water bath and applied to the wood at a temperature of about 60 deg. cent. (140 deg. fahr.). After gluing, the test blocks will be held in clamps and allowed to stand for six additional days. They will then be finished so that the blocks when ready to test will have a glued joint 2 in. square, and will be of the shape shown in the sketch. When tested in this way no test block shall fail under a load of less than 2200 lb. per sq. in., and the average shearing strength shall be at least 2400 lb.

Jelly Strength. The jelly strength will be determined upon a mixture containing twelve parts of water to one part of glue. The glue will be soaked and melted as described under "Adhesiveness," then allowed to stand overnight in a refrigerator at a temperature of 5 to 10 deg. cent. (40 to 50 deg. fahr.). The relative strength of the standard sample and the manufacturer's sample will then be determined by pressure with the finger immediately after the samples are removed from the refrigerator.

Viscosity. The viscosity will be determined in an Engler viscosimeter, upon a sample containing 1 part of glue to 5 parts of water, soaked, and melted as described under "Adhesiveness." Two hundred cu. cm. of the glue mixture will be run through the viscosimeter at a temperature of 60 deg. cent.

Grease. The relative amount of grease present will be determined by mixing dye with some of the sample remaining from the viscosity test, painting it on unsized white paper and observing the appearance.

Foam. The foam will be tested on the sample used for viscosity. The sample, heated to 60 deg. cent., will be beaten for one minute with a power egg beater, or similar instrument, and allowed to stand one minute, or until the height of foam can be measured.

Odor. The odor of the glue when in the hot solution must be sweet, and must remain sweet for forty-eight hours; that is, free from any suggestion of deteriorating animal matter.

Marking. The glue which has been tested and passed shall be barreled in the presence of the Government's representative and marked with the run number, date of run, and inspector's stamp. The glue which is marked in this manner may be sold as certified glue, and its use will be permitted in airplane construction.

Engine Weight Specifications

The committee on engine-weight specifications composed of H. M. Crane, Major J. G. Vincent, C. B. King, Lieutenant Commander A. K. Atkins and J. R. Cautley, submitted the following report:

Manufacturer.....
Model.....
Bore.....in.....mm. Stroke.....in.....mm.
No. of cyl.....Type.....
Piston displacement.....cu. in.....li.
Compression ratio.....

Horsepower.....at.....r.p.m. Computed at standard barometric pressure 29.92 in. (76 cm.), 32 deg. fahr (0 deg. cent.), 45 deg. latitude at sea level.
Gasoline consumption.....lb.....kilo. per hr. at above hp.
Oil consumption.....lb.....kilo. per hr. at above hp.
Propeller speed.....r.p.m. at above engine speed
Weight of engine—dry.....lb.....kilo.

Weight of engine includes the following:

1. Ignition
   Service magneto.
   Wire and wire supports.
   (or) Battery ignition distributor and coils, wire and wire supports.
   Spark-plugs.
2. Generator (if used)
   With cut-out and ammeter.
6. Carbureters.
7. Inlet Pipes.

Above numbers refer to parts given in following schedule:

Comparison of standard water-cooled engines, with rotaries and fixed air-cooled types, may be made by means of schedule of weights.

Give all weights in the following schedule in the proper column, and give names and weights of any other necessary parts not listed.

Mark x if Not Used		Manufactured by	WEIGHTS			
			Included in Above Engine Wt.		Not Included in Above Engine Wt.	
			Lb.	Kilo.	Lb.	Kilo.
	1. Ignition a–Service magneto (No. required....), with attaching bolts or clamps, and complete drive Wire and wire supports Switch b–Starting magneto, with attaching bolts or clamps, and complete drive Wire and wire supports Switch c–Battery ignition distributor (No. required.....), with bolts or clamps and complete drive Coil (No. required .....) Wire with wire supports Switch d–Battery (Capacity.....amp. hr.) (Voltage.....) Box, hold-down clamp and cover e–Spark-plugs (No. required.....)					
	2. Generator (Type of regulation .....) a–Complete with cut-out, regulator, drive, bolts or clamps Is ignition distributor included?..... b–Ammeter (or voltmeter)					
	3. Electric Starter a–Motor with gearshift drive, mounting brackets, strap, bolts and terminals (starting wire on body) b–Starting battery (Cap.....amp. hr.) (Voltage.....) Terminals Switch Box and hold-down clamps					
	4. Compressed Air Starter a–Starter and compressor complete with gearshift, drive, and all piping except between starter and tank b–Air storage tank with straps c–Control valve d–Pipe couplings (piping on body)					

Mark x if Not Used		Manufactured by	WEIGHTS			
			Included in Above Engine Wt.		Not Included in Above Engine Wt.	
			Lb.	Kilo.	Lb.	Kilo.
	5. Hand-Starting Cranks Including attaching bolts and nuts					
	6. Carbureters (No. required.....), with attaching bolts and nuts					
	7. Inlet Pipes With bolts and nuts					
	8. Hot Air Pipes or Stoves					
	9. Exhaust Pipes With flanges and attaching bolts and nuts					
	10. Mufflers (No. required.....)					
	11. Propeller Hub Complete with bolts and nuts					
	12. Gasoline Air Pressure Pump With drive, bolts and nuts (piping on body)					
	13. Gasoline Pump With drive bolts and nuts (piping on body)					
	14. Tachometer Gear Drive on Engine					
	15. Machine Gun Timing Mechanism					
	16. Water Radiator (No. required.....) a–Water radiator connections to engine manifolds					
	17. Oil Radiator or Tank With connections					
	18. Oil Capacity of Crankcase					
	19. Water Capacity of Jackets, Pumps and Manifolds					
	20. Water Capacity of Radiators					

TENSION MEMBERS, ROUND AND STREAMLINE WIRES

G. C. Loening having been appointed a committee of one to recommend proposed standards for streamline wire and tie rods, submitted the following report:

"A study was made of the Royal Aircraft factory practice as adopted by British Aircraft constructors, and known as the A. G. S. Standard Parts. The difficulty encountered immediately was disagreement in thread, size, pins and jaws between the British Standard and the S. A. E. practice. This matter can be overcome only by our translation of this practice into S. A. E. units, the proposed standards covering the proportion and type of fitting developed by the British, but with S. A. E. threads and in size that will correspond with the present S. A. E. standard turnbuckles, using the same size pin and the same jaw as the S. A. E. already adopted, thus making it possible on American airplanes at any time to replace the old type of wiring with the new without having to change any wing fittings. It is pointed out in this connection that the streamline wire detail is in effect nothing more than a continuous turnbuckle in which the wire itself is really the barrel.

"While in Europe the writer was much impressed with the neatness of this fitting and it is clearly capable of very fine manufacturing methods, quantity production, and although at first difficult to make, in the end should result in saving, in doing away with many assembling operations such as soldered loops.

"The streamline wire is not in use in this country, but it is considered a fine opportunity for the S. A. E. to do the leading itself and immediately offer to American aircraft constructors a standard which is far in advance of their own practice, and will result in great improvement of their machines. There is little doubt that streamline wire is in every way a properly engineered design. It has become practically universally adopted on British airplanes already, and should be introduced as quickly in this country."

SPECIFICATIONS FOR VARNISH

The Varnish Committee composed of Percy H. Walker, F. W. Herz, L. V. Pulsifer, and F. H. Lane has considered the requirements for airplane spar varnish and a majority are of the opinion that a proper specification should be based upon the following, which is essentially the specification now in use by the United States Army.

Composition and general properties—"The material shall be the best long oil varnish suitable for application on wood, "doped" linen or cotton, and metal, and resistant to air, light and water. The manufacturer is given the greatest latitude in the selection of raw materials and process of manufacture in order to produce a product of the highest quality."

Physical characteristics—"The material shall comply with the following requirements:

"(1) It shall be clear and transparent.

"(2) Its color shall be no darker than a standard color solution, made by dissolving 6 grams of pure powdered potassium bichromate in 100 c.c. of pure concentrated sulphuric acid (specific gravity 1.84). Gentle heat may be used, if necessary, to secure a perfect solution of the bichromate. The color comparison will be made by placing the varnish and the standard color solution in clear, thin walled glass tubes of the same diameter, 1.5 to 2 cm. (5/8 to 13/16 in.) to a depth of at least 2.5 cm. (1 in.) and comparing the colors by looking through the tubes, across the column of the liquid by transmitted light.

"(3) It shall not flash below 35 deg. cent. (95 deg. fahr.) in an open tester.

"(4) The varnish will be flowed on one side of a 10 x 15 cm. (approx. 4 x 6 in.) panel of bright tin. The panels shall be approximately 0.3 to 0.4 mm. (0.0125 to 0.0158 in.) thick, (90 to 100 lb., weight of base metal per standard box of 112 sheets, 14 x 20 inches, No. 30 to No. 28 U. S. Standard plate gage), and shall be cleaned thoroughly with benzol. When the panel is held in a vertical position and maintained at a temperature of 21 deg. cent. to 32 deg. cent. (70 deg. to 90 deg. fahr.), the varnish shall set to touch at a point not less than 2.5 cm. (1 in.) from the side or top edges of the film, in not more than 5 hr.; and shall dry hard in no more than 24 hr. to a clear, hard, glossy film. The panel will then be allowed to dry for a further period of not less than five days and with the varnished side on the outside, will then be bent double rapidly over a rod 3 mm. (1/8 in.) in diameter. The varnish film shall show no cracking or flaking at the point of bending.

"(5) The varnish will be applied to a basswood panel which has been filled with one coat of drop black in oil thinned with turpentine and drier and allowed to dry for not less than ten days before applying the varnish. It shall have suitable body to give proper brushing, flowing and covering properties. The first coat of varnish will be allowed to dry forty-eight hours, then lightly sandpapered, a second coat applied and allowed to dry seventy-two hours. The panel will then be inclined at an angle of about 45 deg., and a gentle stream of cold tap water allowed to flow down the middle of the panel for eighteen hours. After wiping off with a chamois skin any deposits due to top water the varnish shall show no whitening, dulling, or other defects. A small stream of boiling water will then be allowed to flow down another portion of the panel for twenty minutes. The water will be siphoned through a small glass tube directly from a container in which it is boiling, onto the surface of the panel, in such a manner that there will be no appreciable lowering of the temperature of the water before it touches the varnish film. The siphon delivery tube will be in a plane nearly parallel to the plane of the panel, so that the impact of the water will not tend to break the film. The varnish shall show no appreciable whitening and no more than a very slight dulling or other indications of marked deterioration, either when observed immediately after removing from the water, or after drying for two hours.

NOTE.—In general, results comparable to those given by the above method may be obtained by flowing one coat of varnish on duplicate panels of bright tin thoroughly cleaned with benzol, allowing to dry 48 hr., and then immersing one of the panels in distilled water at room temperature for 18 hr., and the other panel in boiling distilled water for 15 min. But the test on wood should be made in all cases where there is any doubt regarding the resistance of the varnish to water.

"(6) The varnish will be applied in three coats to two unfilled panels of maple wood not less than 14 by 45 by 2 cm. (5 1/2 by 18 by 3 1/4 in.), allowing three days for the drying of each coat. The first coat, after drying indoors for three days, will be sandpapered lightly with No. 00 sandpaper before the application of the next coat. The second and third coats will not be sandpapered or rubbed, and the duplicate panels will be exposed outdoors, 45 deg. to the vertical facing south, three days after the application of the finishing coat. The backs and edges of the panels will also be varnished with the same sample, but for these surfaces the details of the method of application as given need not be adhered to, and the effects of exposure on these surfaces will not be considered. On this

test, the varnish shall show satisfactory durability and weather-resistant properties. In cases where the award of a contract can not be delayed for the results of the exposure test, award may be made on the basis of the other requirements; but a varnish of any specific brand which does not show up satisfactorily on an exposure test may be omitted from consideration in future awards, and a preliminary submittal of samples for making exposure tests may be called for."

The committee now believes that paragraphs 1, 2, 3, 4 and 6 should be incorporated in the proposed specification. It has been suggested that paragraph 5 be modified by applying one coat of varnish to either black iron or tin plate coated with a good quality of black baking japan, allowing to dry from forty-eight hours in a vertical position and then immersing in boiling water for a definite period.

A majority of the committee also believe that the present paragraph 6 be changed to paragraph 7, and that a paragraph be inserted, reading as follows:

"The varnish shall be flamed on one side of a piece of terne plate 10 by 15 cm. (4 by 6 in.), which has been previously thoroughly cleaned with benzol. The coating must extend entirely across the width of the plate and for at least 14 cm. (4½ in.) of the length. The plate shall then be held in a vertical position for six hours at room temperature (21 deg. cent. to 32 deg. cent.) (70 to 90 deg. fahr.). It shall then be placed in an oven at a temperature not less than 135 deg. cent. (275 deg. fahr.) or more than 149 deg. cent. (300 deg. fahr.) for seventeen hours. It will then be removed from the oven, kept at a temperature between 21 deg. cent. (70 deg. fahr.) and 32 deg. cent. (90 deg. fahr.) for not less than six nor more than twenty-four hours. The panel with the varnished side on the outside will then be rapidly bent double over a rod 30 mm. (⅛ in.) diameter at a point not less than 5 cm. (2 in.) or more than 7.5 cm. (3 in.) from the bottom of the plate. The varnish film shall show no cracking or flaking at the point of binding."

It is recommended that copies of the report be distributed to varnish manufacturers and users, with the statement that the committee now proposes to submit definite specifications at the next meeting of the Aeronautic Division. Comments in regard to this specification should be of a constructive nature; that is, they should be explicit specifications submitted in writing.

Meeting of Lighting Division

The meeting of the Lighting Division was held on Oct. 4 at Detroit and was attended by Chairman W. E. McKechine, P. F. Bauder, C. E. Godley, G. L. Sealey and Standards Manager M. W. Hanks.

Head Lamp Illumination.—The Division considered it necessary to cover the point regarding the beam of light rising more than 12 in. above the center of the head lamp in view of the facts presented with reference to headlamp locations on present vehicles. It was therefore suggested on further consideration that the portion of data sheet 38-b, reading, "Nor shall any portion of the direct reflected beam cone of light rise, after the 75-ft. distance, more than 12 in. above the center of the headlamp" be omitted, and "beyond 75 ft. the light may rise slightly but not to exceed 12 in. above the 42-in. level," be inserted.

Classification of Non-Glare Devices.—It was the sense of the meeting that this was not a problem for standardization, but that this offers an excellent subject for a paper.

Reports on other subjects were all in the nature of progress reports. Further information is to be obtained for the next meeting on the subjects of head-lamp bulbs for electric vehicles; road lighting, special consideration being given to spotlight dimensions; signal, side and rear lighting; plugs and sockets; head-lamp lense sizes, and illuminated license plates.

Meeting of Marine Division

A meeting of the Marine Division was held Sept. 26 at New York. W. S. Howard, chairman pro tem, F. S. Duesenberg, E. T. Larkin and Standards Manager M. W. Hanks were present.

A general discussion was held in regard to the tables of a proposed standard engine coupling which should have a standard pilot, bolt holes and centers. A further discussion was on the details and sizes of a standard reverse-gear coupling; also a similar coupling for less particular work, to be made of cast iron. Blueprints from the Portsmouth Navy Yard, and also from the Department at Washington, were submitted by Mr. Howard to show the correctness of the tables. A design of clamp coupling for extension shafts was also submitted.

Considerable time was spent on the propeller mounting, showing detail of keyway, taper and fare-water nut. The table of propeller mountings was adopted. The dimensions for clamp coupling were adopted. The dimensions for the engine coupling and reverse gear were slightly changed in one or two instances to allow a uniformity of jigs for the cast iron and steel types. As soon as new tables showing this can be prepared, they are to be submitted to the members of the Marine Division and a copy sent to the Bureau at Washington for their approval.

Motorcycle Division Meeting

The last meeting of the Motorcycle Division was held at Washington on Oct. 2. Those present were: Capt. William M. Britton, T. C. Butler, Jr., J. W. Graham, Lieut.-Col. U. S. Grant, G. H. Hallock, Capt. F. C. Hecox, C. O. Hedstrom, P. M. Heldt, T. W. Henderson, A. W. Herrington, G. W. Mowry, L. Ogden, F. B. Rodger, G. V. Rottweiler, F. W. Schwinn, G. W. Sutton, Jr., and Standards Manager M. W. Hanks.

Fuel and Lubrication Pipe Fittings.—The drawings for unions were approved by the Division with the understanding that the tolerances be added and that the material used for the nut should be made of steel.

Head-Lamp Supporting Bracket and Mounting Lug.—The dimensions as shown on page 168 of the August JOURNAL were approved by the Division.

Magneto Dimensions.—The dimensions given on page 167 of the August JOURNAL have been completed by extending them to cover the dimensions of the magneto space, as follows:

	Mm.	In.
Height of magneto space	152.4	6.000
Length of magneto space (from large end of shaft taper)	155.58	6.125
Width of magneto space	79.38	3.125
Width at brushes	101.60	4.000

Spoke Dimensions.—With the exception of tolerances the spoke and nipple dimensions were approved for standardization. The spoke length decided on is 10 9/16 in. with a body diameter of 0.120 in. The butt portion is 1.5 in. long with a U. S. F. thread, 40 threads to the inch. The threads may be rolled providing the butt portion is not reduced by this process to less than 1.48 in., which is necessary in order to have a tight fit between the butt and nipple.

Motorcycle Rims.—The Division is desirous of obtaining a rim which will answer for all motorcycle wheels. As the angle of nipple countersink varies with the width and diameter of the hub it will be necessary to decide on some standard angle of countersink in order to make this possible. It is considered probable that a slight change in angle will not materially affect the strength of the wheel. (A meeting of rim manufacturers was held in Washington Oct. 19 to arrange for a standard motorcycle rim.)

Carrying Capacity.—It was approved that the carrying capacity recommendation as voted on at the meeting held June 28th should be changed to read: "The maximum sprung load carrying capacity on military motorcycles and side car shall not exceed 500 lb., including the operator. No load shall be strapped or attached to any part of the frame of either the motorcycle or side car except two rifles and two rifle boots, which may be attached to the front fork."

Cylinder Displacement.—It was approved by the Division that the cylinder displacement of military motorcycle engines for general service should not be less than 60 or more than 61 cu. in.

Lieutenant-Colonel Grant raised a question as to whether the displacement rating was more specific than a horsepower rating. A committee will investigate this question and report on it at the next meeting.

Meeting of Tractor Division

The Tractor Division meeting was held Oct. 6, at the Congress Hotel, Chicago. Those present were: E. R. Greer, C. M. Eason, J. F. Max Patitz, J. T. Greenlee, and Standards Manager M. W. Hanks.

Impulse Magneto Coupling. This subject is still under consideration by the Division. Manufacturers have been asked to submit suggestions in regard to a suitable place for this device.

Connecting-Rod Bearing Dimensions. One of the difficulties encountered in selecting standard connecting-rod bearings is owing to the fact that tractor engines are not designed with the same connecting-rod bearing pressure. This matter is a subject which will require careful consideration and conferences with engine and bearing manufacturers. Joseph Van Blerck was appointed to investigate the possibilities and to make a report at the next meeting.

Drawbar Design. A sample of the drawbar designed by C. M. Eason and made by Mr. Greer, was submitted to the Division. Samples of this have been sent to various manufacturers in order that they may be tried out.

Belt Widths. I. R. Poucher of the Chicago Belting Company sent a table of belt widths for consideration. The Division will be glad to receive any suggestions or criticisms in regard to this table, which is given in full.

TABLE OF TRACTOR BELT WIDTHS

Horsepower	Widths in Inches for		
	4 Ply	5 Ply	6 Ply
12	3	.....	.....
16	4	.....	.....
20	5	4	.....
24	6	5	.....
25	6	5	4
30	7	6	5
32	8	7	5
36	9	8	6
40	10	8	7
48	12	10	8
50	.....	12	10

The above table applies to the use of rubber or canvas stitched belting, having a velocity of 2600 ft. per min. For 4, 5 and 6 ply belting pulleys not less than 8, 10 and 12 in. in diameter respectively should be used. It will contribute to the operating conditions to use pulleys of as large diameter as practical to secure the accepted velocity of 2600 ft. per min. It is desirable and good practice to favor width instead of thickness with the exception that 4-ply belts should not be used in widths above 12 in.

Activities of S. A. E. Sections

THE paper presented by President George Dunham at a combined meeting of the Buffalo Section of the Society and Buffalo Engineering Society is given in complete form in this issue. This paper was presented at a meeting held Oct. 10 in Buffalo, which was attended by nearly five hundred engineers. President Dunham closed his paper by a strong plea for additional members of the Society in order to carry on the work of the Buffalo Section. Mr. Dunham's appeal was seconded by F. A. Lidbury, president of the Engineering Society of Buffalo, by Second Vice-President Charles M. Manly and others.

The Buffalo Section of the Society is unique in that it is an affiliated section of a strong local engineering society with which are also affiliated local organizations of the American Chemical Society, the Electro Chemical Society and the American Society of Mechanical Engineers. The arrangement under which the work is being carried on in Buffalo being very advantageous, particularly where the local sections of the National Engineering Societies are small and might have difficulty in carrying their work on alone. For that reason an announcement recently appearing in the *Bulletin* of the Engineering Society of Buffalo, and written by its president, is quoted here in practically complete form:

"The sixth season of the Engineering Society of Buffalo finds the Society broadening its activities. It has affiliated with it all local sections of national engineering and chemical societies at present existing in Buffalo and vicinity, and there is a good prospect of this step resulting in the formation of local sections of other national engineering societies in Buffalo. The arrangements arrived at involve the holding, once monthly, on the second Wednesday each month during the season, of general meetings of the Engineering Society of Buffalo, and on each other Wednesday of a meeting of one of the local sections or of a special meeting of the Society. Members of the Engineering Society of Buffalo and of the affiliated sections will all receive notification, by monthly bulletin, of the program for the ensuing month, and each is not only privileged but specifically invited to attend any of the meetings in which he is interested, and the informal dinners by which the general meetings, as well as most of the sectional meetings, will be preceded.

"The officers of the Society and of the affiliated sections have done their part by arranging a program which well carries out the intention that the general meetings should be reserved for subjects of general engineering interest, and as far as possible subjects bear-

ing upon engineering matters connected with the war; and that the meetings of the sections should be held on subjects which, while primarily of specialized interest, are so selected as to be also of interest to engineers engaged in other lines of work. Owing to the serious demands which present conditions have made upon the time and attention of all it has been a difficult matter to arrange a program so as to secure as speakers men of the highest authority on the subjects chosen; but it has been done, though the program for the season is not complete and though the unexpected calls to which engineers of prominence are subject may involve alteration as the season proceeds. We have no hesitation in assuring members, however, that all meetings, both of the Society and of the sections, will be of intense interest both as regards subjects and speakers.

"The success of the season is now in the hands of the members. The executive committee of the Society and the officers of the sections will do everything possible on their part; but they cannot do for attendance and membership one-tenth part of what the members themselves can do. All members are therefore urged to continue the upbuilding and growth of the Society by their co-operation."

Practically all of the Sections of the Society will hold meetings during the current month. The meeting of the Buffalo Section will be held on the 24th, at which Otto M. Burkhardt will deliver a paper on crankshaft problems. The Cleveland meeting took place on the 19th, and was devoted to a discussion of aviation. The Detroit meeting on the 18th was devoted to a discussion of Laboratory Testing, the paper being presented by a committee having that matter in charge.

The Indiana Section will hold its first meeting on the 26th. Practically all the officers of the Section with the exception of two have been called away on war work, so that the first meeting will be devoted to business matters and to a discussion of plans for the coming year. The Metropolitan Section will hold its monthly meeting on the 25th at the Automobile Club of America. G. Douglas Wardrop, editor of *Aerial Age*, will deliver an illustrated lecture entitled, "The War in the Air." An officer representing the Aviation Section of the U. S. A. will also be present and will talk on personnel needs of the Aviation Section. The first of the Pennsylvania Section meetings, to be devoted to the riding qualities of motor vehicles, will be held on the 25th at the Engineers' Club in Philadelphia. Walter C. Keys is to deliver a paper on the problem involved in spring suspension.

Cleveland Section Activities

By Chairman W. R. Strickland.

The current year opens auspiciously for the Cleveland Section of the Society of Automotive Engineers. The present officers are as follows: W. R. Strickland, chairman; A. M. Dean, vice-chairman; H. G. Welfare, secretary; H. C. Snow, treasurer. The committee chairmen are: G. W. Smith, membership; R. S. Begg, meetings; E. W. Weaver, papers; B. M. Short, entertainment; F. H. Laning, publicity.

Special effort is being made to so administer the affairs of the Society that the result of the year's work will be profitable to the industry, the Society and the nation.

The first meeting was held September 21st. It was preceded by a dinner, and the attendance was satisfactory. Meetings will be continued throughout the season, and will be held on the third Friday of each month. It is planned to precede each of the meetings by a dinner.

The Governing Committee of the Section is holding monthly luncheon sessions, at which plans are discussed and action taken. The interchange of ideas has proven beneficial to the Sectional activities.

At present the Cleveland Section membership consists of 267 associates and 95 members. We hope during the coming year to increase this materially with more than double our membership this last year, and have every reason to believe that more interest is being taken than ever in our work.

The next meeting will be held at Hotel Olmstead, and undoubtedly this hotel will be the location of most of our meetings in the future. We wish to extend a cordial invitation to any S. A. E. members who may happen to be in Cleveland on the third Friday of any month to get in touch with H. G. Welfare, Edgewater 1100, or B. M. Short, Rosedale 2923, and join us at supper and attend the meeting.

We hope some day to have permanent rooms where we can serve noonday lunches and have more or less of a club aspect. At the present time this stage has not been reached.

It is not possible at this time to announce the subjects for the coming meetings, but measures have been taken and plans well advanced for a number of most interesting papers and discussions. All in all it would seem that the current season will be one of the most profitable which the Cleveland Section has experienced.

Detroit Section Activities

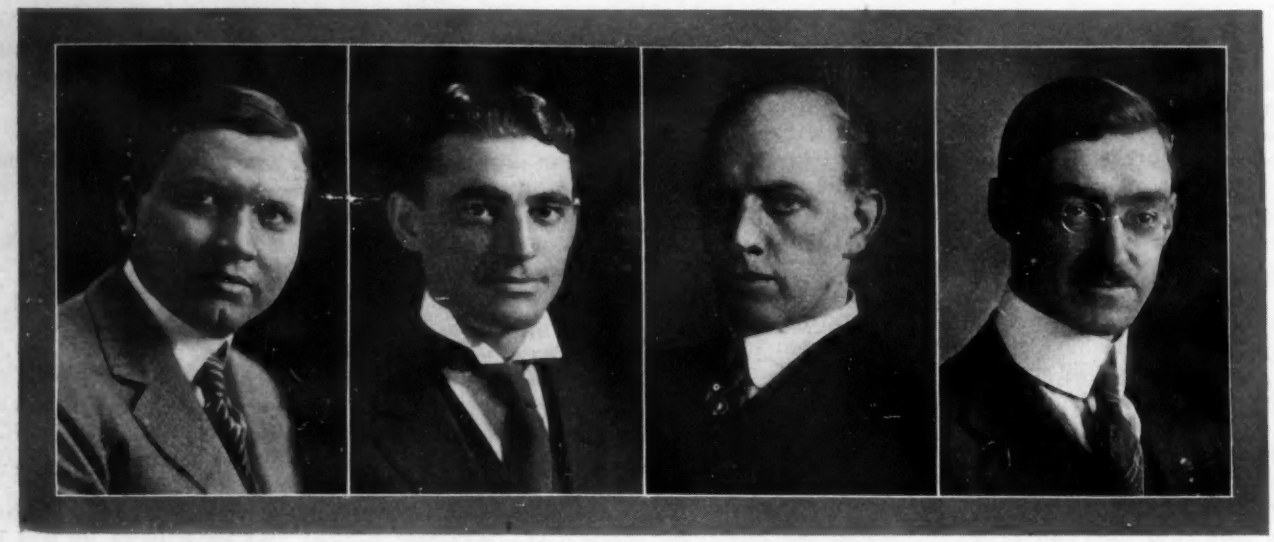
By Chairman C. C. Hinkley.

The Detroit Section formally opened its winter season Sept. 14, with an interesting meeting on the subject of Metallurgy and Chemistry as Applied to the Automotive Industry. This paper was written by the Chemical and Metallurgical Division of the Industrial Research Committee, composed of R. H. Sherry, Chairman, A. E. DeClerq, K. M. Wise, F. Wahl and F. E. McCleary. A large number of the Detroit Section members were present, and their interest in the subject was displayed by a lively discussion which followed the reading of the paper.

Plans for the October meeting are nearing completion, and present indications lead us to believe that this meeting will be one of the star events of the season. A paper has been prepared on Laboratory Testing by that branch of the Industrial Research Committee. R. M. Anderson is chairman, O. C. Kreis and Fred C. Wendland are committee members. Such items as the amount of gasoline that is actually available as energy to propel a car, what is considered the greatest allowable gas velocity through the valves, how to get the last ounce of horsepower out of an engine, will be discussed. To illustrate the various subjects touched upon lantern slides will be used. This will give the person who has never had an opportunity to inspect a laboratory an idea of just how tests are conducted.

The November meeting also promises to be one of unusual interest. At that meeting, the date of which we are unable to announce at this time, a paper will be delivered on Planning and Mechanical Efficiency. The committee preparing this is composed of Geo. C. McMullen, chairman, C. W. Avery and C. A. Marston. Through the courtesy of the Ford Motor Company, a moving picture machine has been secured, and films will be shown of various assembling processes, handling of stock, and general factory routine.

The matter of having a meeting in December has not



Detroit Section Officers. Left to Right—C. C. Hinkley, Chairman; George M. Holley, Treasurer; F. A. Whitten, Vice-Chairman, and Wm. B. Stout, Secretary.

yet been definitely decided upon, but it is very likely that we will hold an open meeting as a sort of "Members' Rally."

January is the month of automobile shows, and in order that our members may give their attention to this activity a meeting will not be held.

We consider February the month of art, in so far as the Detroit Section is concerned, for during this month a paper will be given by the Body Division, which consists of E. W. Goodwin, John Allmand, L. C. Hill and C. H. Wilson. While the average person concerns himself mostly about the mechanical parts of his car, the importance of the body, wherein we ride, must not be overlooked. In the construction of the bare body itself perhaps 50 per cent of the floor space of the entire plant is required. This is due to the very nature of the work to be done. After the body frame has been covered with sheet steel or aluminum, as the case may be, it proceeds to the paint shop, where my lady's taste is satisfied. Last of all the instrument board, instruments, door levers, robe rails, etc., are put on. The paper on this subject, to be written by men that know the body game from A to Z, should pave the way for the discussion.

The last professional meeting of the season will be held in March. This meeting will be conducted by the Inspection Division of the Industrial Research Committee, of which H. M. Jerome is chairman, and C. E. Stark, R. A. Vail and J. W. Whitaker members. Inspection as Applied to the Automotive Industry will be the title of the paper, and many items of interest and education will be brought out.

In closing we wish to announce that the present membership of the Detroit Section is 1160, of which 802 are Section Associates and the remainder, 358, are Section Members. Up to the present time the Detroit Section has been much the same as a favorite regiment in the army, whose ranks are filled up as fast as they are depleted. We are continually losing members by their being called to the front, but our membership is steadily increasing in spite of the war.

NOMINEES FOR SOCIETY OFFICERS

The 1917 Annual Nominating Committee provided for by paragraph 46 of the Constitution has completed its work. In accordance with the By-Laws, the committee organized at the time of the meeting of the Society held last June in Washington. The committee has sent to the office of the Society the names of consenting nominees for the elective officers next falling vacant under the Constitution, as follows:

For President (to serve for one year), C. F. Kettering.

For First Vice-President (to serve for one year), David Beecroft.

For Second Vice-President, representing Motor-Car Engineering (to serve for one year), C. C. Hinkley.

For Second Vice-President, representing Aviation Engineering (to serve for one year), George H. Houston.

For Second Vice-President, representing Tractor Engineering (to serve for one year), Fred Glover.

For Second Vice-President, representing Marine Engineering (to serve for one year), Henry R. Sutphen.

For Second Vice-President, representing Stationary Internal-Combustion Engineering (to serve for one year), H. R. Brate.

For members of the Council (to serve for two years), Charles S. Crawford, Charles M. Manly, J. V. Whitbeck.

For Treasurer (to serve for one year), Charles B. Whittelsey.

The Nominating Committee was constituted of three Members elected at the business session at the last Society Meeting and eight members elected by the eight Sections of the Society, as follows:

David Fergusson, Buffalo Section, who acted as chairman of the committee; K. H. Brown, Cleveland Section; L. D. Bolton, Detroit Section; F. E. Moskovics, Indiana Section; N. B. Pope, Metropolitan Section; G. W. Smith, Mid-West Section; E. R. Greer, Minneapolis Section; W. H. Palmer, Jr., Pennsylvania Section.

Ballots bearing the names of the candidates for office proposed for election will be mailed to each member entitled to vote prior to the next Annual Meeting. At the first session of the 1917 Annual Meeting tellers will canvass the ballot and certify the result to the meeting.

REPORT OF OCTOBER COUNCIL MEETING

THE October meeting of the Council was held on the 8th at the Washington office of the Society, those present being President George W. Dunham, Second Vice-President Charles M. Manley, Councilors David Beecroft, B. B. Bachman, H. L. Horning, C. W. McKinley, J. G. Utz, Treasurer Herbert Chase and General Manager Coker F. Clarkson.

Councilor Beecroft presented a report as Chairman of the Meeting Committee of the Society showing that the National Automobile Chamber of Commerce had designated Thursday, Jan. 10, as S. A. E. day, during the week of the New York show. Tentative arrangements have been made to hold a dinner on the evening of that day at the Hotel Biltmore. A meeting is to be held Feb. 1 at Chicago and a dinner in the evening at the Hotel LaSalle. Arrangements are now being made to hold professional sessions on both days mentioned.

A report was presented for the Membership Committee showing that 1311 applications had been received from Jan. 1 to Oct. 6, 1917, and that 1140 applications had been approved during the months of January to September inclusive, this including 23 applications for Affiliate Membership with 49 Affiliate Representatives and 58 applications for Student Enrollment.

It was voted to make the following transfers in grade of membership, from Associate to Member grade: E. L. Usner and A. F. Wagner.

Applicants to the number of 71 were elected to membership in the Society, these being assigned to grades, as follows: 13 Members, 33 Associate Members, 7 Junior Members, 5 Affiliate members, 11 Affiliate Member Representatives, and 2 Student Enrollment.

Councilor Bachman presented a report as Chairman of the Constitution Committee to the effect that the possibilities of establishing a foreign grade of membership were under consideration by his committee and that definite recommendation would be made in the near future.

It was the sense of the Council that General Manager Clarkson should prepare a report regarding the advisability of establishing a united service grade of membership, this to be submitted at the next meeting.

A report was received from Chairman Daniel Roesch of the Publication Committee showing that this committee had prepared Part I of the 1917 Transactions of the Society and that the volume was now being sent to all the members. Plans are under way for issuing Part II of the Transactions by the Publication Committee.

A letter from J. E. Hale suggesting that the Society secure engineering data as a basis for logical legislation regarding the liable maximum load carried by the truck tires of various widths was presented to the Council and the matter referred to the Research Division for consideration.

Chairman F. G. Diffin of the International Aircraft Standards Board appeared before the Council and stated that the Society was requested to appoint two members to represent it on the Board. The Council voted to cooperate with the International Aircraft Standards Board and President Dunham appointed Vice-president Chas. M. Manly and General Manager Coker F. Clarkson as the S. A. E. representatives.

It was stated that the International Aircraft Standards Board was considering the possibility of adopting the metric system of measurements for aeronautic purposes within a certain period after the war. After considerable discussion the Council decided that in view of the action taken by the Aeronautic Division of the Standards Committee the change to the metric system was not desirable, but that if further action was desired a vote should be taken by the members of the Society before it should be committed to further action.

A committee consisting of Councilor Utz, Treasurer Chase, and General Manager Clarkson was appointed to report on questions pertaining to the cooperation of the Society with the proposed American Engineering Standards Committee.

It was voted that General Manager Clarkson take up with the management of the Automobile, Tractor, Aeronautic and Motor Boat Shows the question of exhibiting S. A. E. Standards and arrange for such exhibits insofar as they may prove practicable.

Councilor Bachman as Chairman of the Sections Committee reported that all of the sections that had enrolled Section Associates had voted to adopt the recommendations of the Sections Committee as agreed upon at a meeting held in Washington last June, the only exception being the Cleveland Section, which had voted to establish slightly lower dues than recommended by the Sections Committee. The Council approved the amendment to the By-Laws as recommended by the Sections Committee, with the exception of the change in SB 10 suggested by the Cleveland Section. It was recommended that this section consider the matter further with a view to making its dues for Section Associates uniform with those adopted by the other sections.

A report was presented from the Tellers appointed to count the ballots cast in connection with amendments to paragraphs 8, 9, 10 and 45 of the Constitution of the Society. These were proposed and discussed at the Society meeting in January, 1917, and discussed and amended at the Society meeting in June, 1917. The Tellers, A. B. Cumner, R. McA. Lloyd and L. C. Marburg, reported the adoption of these amendments by vote as follows:

Ballots favoring adoption of proposed amendments, 531.

Ballots not favoring adoption of proposed amendments, 4.

Defective ballots, 1.

Total number of votes cast, 536.

A letter was received from Phineas V. Stephens requesting that the Society appoint a representative to serve on the Engineering and Research Committee of the Southern Commercial Congress to be held at New York during October. It was voted to designate H. G. McComb to act as representative of the Society at this Congress.

It was the sense of the Council that an outline of the early history of the Society be prepared, it being understood that H. M. Swetland has consented to assist in the preparation of this history. Steps will also be taken to prepare a current history covering the works of members of the Society in the Government service.

It was voted that the Society ask Brigadier-General Chauncey B. Baker of the Quartermaster Corps for per-

mission to have inscribed on the name plates to be used on the U. S. A. military trucks a statement to the effect that the Society and its members had cooperated in their design.

The next meeting of the Council will be held November 12 at Washington.

HONOR ROLL OF MEMBERS OF THE SOCIETY

Barton, W. E., first lieutenant, Quartermaster Corps, Washington, D. C.

Blood, Howard E., first lieutenant, Signal Corps, U. S. A., Washington, D. C., assigned to Engine Design Section, Equipment Division.

Capron, Webster A., captain, Field Artillery, U. S. A., assigned to duty in connection with motorization in office of Chief of Ordnance.

Forrer, J. D., captain, Engineer Officers' Reserve Corps, Washington, D. C.

Gardner, Lester D., captain, Signal Corps, U. S. A., Washington, D. C.

Guthrie, James, major, U. S. A., Washington, D. C.

Gfrorer, A. H., first lieutenant, Ordnance Division, Officers' Reserve Corps, U. S. A., Washington, D. C.

LeFevre, Wm. G., lieutenant, Ordnance Dept., U. S. A., Washington, D. C.

Lewis, Harry R., Jr., first lieutenant, Ordnance Officers' Reserve Corps, U. S. A., Springfield Armory, Springfield, Mass.

McIntyre, H. C., captain, Ordnance Department, U. S. A., Washington, D. C.

Ommundson, H. P., Naval Flying Corps, Washington, D. C., stationed with Co. 4, Section 1, U. S. N. Aeronautic Station, Pensacola, Fla.

Ranney, A. Elliot, major, Signal Corps, U. S. A., Washington, D. C.

Rose, C. B., captain, Equipment Division, Signal Corps, U. S. A., Washington, D. C.

Sligh, Charles R., major, Signal Corps, U. S. A., Washington, D. C., assigned to wood section, Equipment Division.

PERSONAL NOTES

Porter H. Adams has been assigned to duty at the office of the Section Commander, First Naval District, Rockland, Me.

C. E. F. Ahlm, formerly chief engineer of Elwell-Parker Electric Co., Cleveland, is now located independently at 315 Caxton Building, Cleveland.

W. D. Appel, formerly consulting engineer, Cleveland, is now in the experimental engine department, Curtiss Aeroplane & Motor Corp., Buffalo.

J. W. Applin, formerly designer, Cadillac Motor Car Co., Detroit, is now chassis engineer with the same company.

Charles O. Ball, formerly consulting engineer, Gas-Electric Motorbus Corp., New York, is now engineer and general manager of same company at Chicago.

Claire L. Barnes, formerly at 5470 Hyde Park Boulevard, is now president and general manager of the Barnes Foundry & Mfg. Co., Detroit.

F. H. Berger is now chief engineer and designer, Abbott Corp., Cleveland.

W. J. Burdick, formerly manager, chassis division, Reed & Glaser, Indianapolis, is now director and purchasing agent, Cruiser Motor Car Co., Madison, Wis., at Chicago.

W. P. Berrien, formerly vice-president and sales manager, the Batavia Rubber Co., Batavia, N. Y., is now located at Room 125, 97 Warren Street, New York.

Charles E. Broad, formerly engineer, Stanley Motor Carriage Co., Newton, Mass., is now chief engineer of the same company.

, Roger Chauveau, Signal Corps, U. S. A., Washington, D. C., assigned to duty as aeronautical mechanical engineer.

W. P. Chrysler, formerly works manager of the Buick Motor Co., Flint, Mich., is now president and general manager of the same company.

Arthur L. Collins, formerly metallurgist, Atlas Ball Co., Philadelphia, Pa., is now engineer of tests with the same company.

R. H. Collins, formerly with General Motors Co., is now with the Cadillac Motor Car Co., Detroit.

F. A. Cornell, formerly assistant general sales manager, Cole Motor Car Co., is now eastern representative, Timken Roller Bearing Co., Buffalo.

Harold I. Crow, formerly layout draftsman, Mercer Automobile Co., Trenton, N. J., is now instructor on aeronautical engines, School of Military Aeronautics, University of California, Berkeley, Cal.

M. E. Crow, formerly president of the Crow-Elkhart Motor Co., Elkhart, Ind., is now president and general manager of the same company.

Col. Edward A. Deeds has been assigned to the Equipment Division of the Signal Corps, U. S. A.

W. H. DeVaney, formerly president of Hoosier Castings Co., Connersville, Ind., is now with the Gartland-Toledo Foundry Co., Toledo.

F. G. Diffin, formerly president, Erie Specialty Co., Erie, Pa., is now chairman of the International Aircraft Standards Board, Washington, D. C.

A. C. Duncan, formerly with the Globe Motor Truck Co., E. St. Louis, Ill., is now student officer in Balloon School at Fort Omaha, Omaha, Neb.

Capt. Matthew Farrell, formerly stationed at the Pierce-Arrow Motor Car Co., Buffalo, is now at Room 205, Union Station Building, Washington, D. C.

Thomas F. Frewen, formerly designer at Timken Detroit Axle Co., is now designer with the Lincoln Motor Co., Detroit.

G. W. Gail, Jr., formerly student, Cornell University, is now mechanical engineer, Curtiss Aeroplane & Motor Corp., Buffalo.

G. F. Getschman, formerly foreman, Parker Motor Car Co., Seattle, Wash., now has his own repair shop at 1015 Pike Street, Seattle, Wash.

C. S. Gmeiner, formerly consulting and designing engineer at Detroit, is now consulting and efficiency engineer with the States Motor Car Co. at Kalamazoo, Mich.

Arthur N. Goodfellow, formerly manager, Detroit office, Standard Roller Bearing Co., Philadelphia, is now western sales manager, Nice Ball Bearing Co., Nicetown, Pa.

W. E. Hamilton, formerly efficiency engineer, Premier Motor Corp., Indianapolis, is now at 1307 N. La Salle Street, Indianapolis.

A. A. Hartmann, formerly student at Rensselaer Polytechnic Institute, Troy, N. Y., was drafted for the National Army and is now with the 304th Infantry of Connecticut at Camp Devens, Ayer, Mass.

William M. Harty, formerly general manager, the Cooper Spring Co., Cleveland, is now manager and engineer of the same company.

H. L. Horning, formerly engineer of Waukesha Motor Co., Waukesha, Wis., is now general manager and secretary of the same company.

F. R. Hoyt, formerly chief engineer, Menominee Electric Products Co., is now in the Aviation Section, Signal Corps, U. S. A., Washington, D. C.

S. H. Humphrey, formerly first vice-president and manufacturing manager, Briscoe Motor Corp., is now factory manager, Wright-Martin Aircraft Corp., New Brunswick, N. J.

C. F. Johnson, formerly consulting engineer, Johnson Co. and Cadillac Motor Co., is now engineer, Johnson Co., Detroit.

Royal K. Johnson, formerly engineer, Garford Engineering Co., Elyria, Ohio, is now doing consulting engineering work at Cleveland.

Fred Keller, Jr., formerly draftsman, Sphinx Fuel Devices Co., is now with the Aeromarine Plane & Motor Co., Keyport, N. J.

W. P. Kiser, formerly secretary and assistant general manager, Chalmers Motor Co., is now vice-president and general manager, Chalkis Mfg. Co., Detroit.

Herman J. Kline, formerly at Fort Sheridan, Ill., has been transferred to Company 5, Officers' Reserve Training Camp, Fortress Monroe.

E. K. Leech, formerly president, Chalsmith Sales Corp. of New York, is now with the O. J. Gude Co., New York.

C. J. Kleinjohn, formerly assistant chief inspector, Premier Motor Corp., is now with the Curtiss Aeroplane & Motor Corp., Hammondsport, N. Y.

Henry M. Leland, formerly president and advisory manager, Cadillac Motor Car Co., Detroit, is now president, Lincoln Motor Co., Detroit.

Grover C. Loening, formerly consulting aeronautical engineer at 60 Wall Street, is now with Loening Aeronautical Engineering Corp. at Long Island City, N. Y.

Glenn L. Martin, formerly superintendent Wright-Martin Aircraft Corp., New York, is now with the Glenn L. Martin Co., Cleveland.

Marcenus D. McMaster, Signal Corps, U. S. A., Washington, D. C., assigned to Equipment Division as aeronautical mechanical engineer.

A. C. Mason, formerly president and general manager, Mason Motor Co., Flint, Mich., is now consulting engineer, Chevrolet Motor Co., at New York.

George E. McGill, formerly draftsman, Van Blerck Motor Co., Monroe, Mich., was drafted for the National Army and is now with the 85th Division Military Police, Company No. 2, Camp Custer, Battle Creek, Mich.

E. W. McGookin, formerly vice-president and sales manager, Springfield Body Corp., Springwells, Mich., is now owner of the E. W. McGookin Co., 1231 Woodward Avenue, Detroit.

G. P. McNiff, formerly metallurgical engineer, Shelby Steel Tube Co., Pittsburgh, is now metallurgical engineer, National Tube Co. of the same city.

Edgar Menderson, formerly assistant to the Philadelphia district representative, is now sales manager, the Mason Towle Co., Cincinnati.

E. E. Minard, formerly sales and engineering representative, Detroit Pneumatic Chuck Co., Detroit, and Bloomquist-Eck Machine & Mfg. Co., Cleveland, is now salesman and engineer, J. R. Stone Tool & Supply Co., Detroit.

Herbert A. Minturn, formerly engineer, Sun Motor Car Co., is now service manager, Pilot Motor Car Co., Richmond, Ind.

George L. Moskovics, formerly sales engineer with the George Automatic Roller Bearing Co., Cincinnati, is now in the sales department of the Mitchell Motor Co., Inc., Racine, Wis.

Harold E. Morehouse, formerly draftsman, Van Blerck Motor Co., is now designing layout draftsman with Dayton Wright Airplane Co., Dayton, Ohio.

F. E. Moskovics, formerly commercial manager, Nordyke & Marmon Co., Indianapolis, is now vice-president of the same company.

C. S. Mott, formerly president of Weston-Mott Co. and vice-president General Motors Co., is now only vice-president of General Motors Co., Flint, Mich.

R. G. Nelson, formerly assistant sales manager, McGraw Tire & Rubber Co., E. Palestine, Ohio, is now director of sales with the same company.

John W. Neumann, formerly carbureter engineer, Detroit Lubricator Co., Detroit, is now in planning section, machine division, U. S. Navy Yard, Philadelphia.

Lee W. Oldfield, formerly engineer and president, Oldfield Motors Corp., Minneapolis, is now chief engineer, Moore Motor Vehicle Co., Minneapolis.

Charles B. Page, formerly general manager, Duesenberg Motors Corp., Chicago, is now works manager of same company at Elizabeth, N. J.

R. R. Potter, formerly chief engineer, Blood Bros. Machine Co., is now production engineer, Fuller & Sons Mfg. Co., Kalamazoo, Mich.

Karl F. Ranger, formerly with the Durston Gear Co., is now with the Lincoln Motor Co., Detroit.

H. A. Raseley, formerly sales manager, Australasian Division, General Motors Export Co., New York, has resigned with the intention of locating in the Middle West.

H. K. Reinoehl, formerly chief engineer and production manager, the A. Howard Co., is now chief engineer, the Turnbull Motor Truck & Wagon Co., Defiance, Ohio.

Louis F. Renault, formerly designing engineer, Gas-Electric Motor Bus Corp., New York, is now chief draftsman of the same company in Chicago.

Harvey M. Rice, formerly with the Continental Motors Corp., Detroit, is now in the Signal Corps, U. S. A., stationed at Curtiss Aeroplane Co., as inspector of aircraft engines and equipment.

O. J. Rohde is now New York service manager, Wire Wheel Corp. of America.

Edward V. Salisbury, formerly automobile expert, Ordnance Department, U. S. A., Rock Island, Ill., is now chief of motor transportation, American International Corp., Philadelphia, Pa., stationed at the Government Shipbuilding Yard, Hog Island, Philadelphia.

Arthur A. Schupp, Signal Service at Large, Signal Corps, U. S. A, Washington, D. C., assigned to aviation section as aeronautical mechanical engineer.

C. C. Stevens, formerly draftsman, Ordnance Department, U. S. A., Washington, is now designer with the New Departure Mfg. Co., Bristol, Conn.

A. T. Sturt, formerly engineer, Chevrolet Motor Co., Flint, Mich., is now chief engineer with the same company at New York.

C. E. Thompson, formerly president, the Steel Products Co., Cleveland, is now president, the Glenn L. Martin Co., Cleveland.

Percy Wheeler Tracy, formerly director of purchases, Premier Motor Corp., Indianapolis, is now supervisor of parts plants, Military Truck Production Section, O. Q. M. G., U. S. A., Washington.

Henry M. Van Loon, formerly designer at Detroit, is now with Company E, 310th Engineers, Camp Custer, Battle Creek, Mich.

Col. Sidney D. Waldron has been assigned to the Equipment Division of the Signal Corps, U. S. A.

E. W. Winans, formerly chief engineer, Regal Motor Car Co., Detroit, is now engineer in charge of service, Federal Motor Truck Co., Detroit.

T. Yu, formerly aeronautical engineer, Curtiss Aeroplane & Motor Corp., Buffalo, is now connected with the Hsu Kai Shau Company at Chinkiang, China.

GEORGE W. HOUK

The passing of George W. Houk occurred Oct. 6 at Hollywood, Cal. His decease followed a second attack of the paralysis with which he was first stricken less than a month ago.

Mr. Houk was born Nov. 7, 1865, in Wellsboro, Pa. He entered the bicycle business in its early days, and from 1892 to 1896 was sales manager for the Eclipse Manufacturing Co., first at Beaver Falls and then at Elmira, N. Y. Subsequently he went to England and organized the firm of Green & Houk, Ltd., at London, for the marketing of Eclipse and other coaster brakes.

Returning to this country in 1909, he was for about a year manager of the Oldsmobile Company of Massachusetts. About this time he became interested in automobile lamps, introducing several English designs into this country and inventing an adjustable lamp bracket that was once in general use abroad.

Mr. Houk was the introducer in this country of the Rudge-Whitworth detachable wire wheel. In 1913 he was general sales agent for this product with the Standard Roller Bearing Co. of Philadelphia, but later he started his own company at Buffalo, and last March disposed of his interests in it to the Wire-Wheel Corporation of America.

His death occurred at his ranch in Southern California, where he was president of the Northern San Diego Chamber of Commerce.

He leaves only a daughter, Mrs. Margaret Houk Moody, his wife having died a number of years ago abroad. Mr. Houk was on May 19, 1913, elected an Associate Member of the Society.

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ADAMS, FLOYD W., stock chaser, Buick Motor Co., *Flint, Mich.*

ADAMS, RALPH L., designer, Edward G. Budd Mfg. Co., *Philadelphia.*

BARNABY, RALPH STANTON, head of engineering department, Standard Aero Corp. of New York, *Plainfield, N. J.*

BARNES, HAROLD H., chief draftsman, Continental Motors Corp., *Detroit.*

BATES, H. H., vice-president, Joliet Oil Tractor Co., *Joliet, Ill.*

BENOIT, LEO G., mechanical draftsman, Tips Aero Motor Co., Inc., *Woonsocket, R. I.*

BLACK, ARCHIBALD, chief engineer, L. W. F. Engineering Co., *College Point, N. Y.*

BRASELTON, CHESTER H., patent counsel, Willys Overland Co., *Toledo.*

BRITTEN, DANIEL LINDERMAN, assistant general manager, Commercial Car Unit Co., *Philadelphia.*

CARDULLO, FORREST E., materials testing engineer, Curtiss Aeroplane Co., *Buffalo.*

CARNEY, JAMES M., vice-president, Hartford Auto Parts Co., *Hartford, Conn.*

CLAASSEN, CHAS. W., buyer, C. & D. Auto Supply Co., *Cincinnati.*

CLODIO, PAUL V., president, Houdaille Shock Absorber Co., Inc., *New York.*

COFFIN, HOWARD A., manager, Wheel Division, Detroit Pressed Steel Co., *Detroit.*

COHEN, EDWARD S., general superintendent, Lycoming Foundry & Machine Co., *Williamsport, Pa.*

COSGROVE, ROWE H., student, mechanical engineering, University of Michigan, *Ann Arbor, Mich.*

DAVIDGE, ALFRED VINCENT, chief draftsman, The Austin Motor Co., *Birmingham, Eng.*

DAY, ALFRED L., designing engineer, 1454 Hyde Park Blvd., *Chicago.*

EDMONDSON, D. E., inspector of airplanes and airplane engines, Signal Service at Large, *Buffalo.*

EK, G. A., mechanical draftsman, Minneapolis Steel & Machinery Co., *Minneapolis.*

ERD, HARRY S., sales manager, Erd Motor Co., *Saginaw, Mich.*

ERICSON, JOHN ROBERT, designer, Jordan Motor Car Co., *Cleveland.*

FIELD, CHARLES F., general manager, Field Brundage Engine Works, *Jackson, Mich.*

FREY, AUGUST, purchasing agent, Harley-Davidson Motor Co., *Milwaukee, Wis.*

HARTER, EVAN CHARLES, president, Metal Forming Corp., *Elkhart, Ind.*

HAZEN, ARTHUR J., assistant chief draftsman, The Kissel Motor Car Co., *Hartford, Wis.*

HEATH, FRANK C., works manager, Federal Brass Works, *Detroit.*

HOLLERITH, HERMAN, research department, The White Motor Co., *Cleveland.*

HOLMES, ARTHUR, president, Holmes Automobile Co., *Canton, Ohio.*

HOOTH, KARL W., assistant engineer, Fuller & Sons Mfg. Co., *Kalamazoo, Mich.*

HOUMER, ANDRE LOUIS, mechanical engineer, 441 W. 22d St., *New York.*

HUNSAKER, JEROME CLARKE, assistant naval constructor, U. S. Navy, *Washington, D. C.*

JACO, ESTILL L., designing engineer, *Charles City, Iowa.*

JONES, EDWARD L., salesman, Standard Parts Co., *Cleveland.*

KENT, RICHARD, draftsman, Holt Manufacturing Co., *Peoria, Ill.*

KINNUNEN, KUNO, president, O/Y Power Co., Ltd., *Wiborg, Finland.*

LOCKE, ERIC S., head of drafting room, Hall-Scott Motor Car Co., *Berkeley, Cal.*

MATTSON, J. L., vice-president, Deming Tractor Co., *Cedar Rapids, Iowa.*

MCINTOSH, JOHN M., assistant supervisor, parts plants, Standard Parts Co., *Cleveland.*

MCKAY, W. A., commercial engineer, H. W. McCandless & Co., *New York.*

MCKONE, FRANK EDWARD, assistant professor mechanical engineering, University of Washington, *Seattle, Wash.*

MCLAUGHLIN, CORNELIUS D., aeronautical mechanical engineer, Signal Service at Large, Aircraft Inspection Training Office, *Buffalo.*

MILLER, B. F., captain Quartermaster Corps, U. S. Army, *Washington, D. C.*

MOLLOY, EDDIE, chief engineer, Loening Aeronautical Engineering Corp., *Long Island City, N. Y.*

MOTT, THOS. T., service representative, Chalmers Motor Co., *Detroit.*

NERICHER, W. A., vice-president, General Fire Extinguisher Co., *Warren, Ohio.*

NOTMAN, ROBERT L., factory manager, Militaire Motor Vehicle Co., *Buffalo.*

OCHTMAN, LEONARD, assistant to chief draftsman, Van Blerck Motor Co., *Monroe, Mich.*

ORTON EDWARD, JR., major, office of Quartermaster General, U. S. Army, *Washington, D. C.*

PARRISH, WALTER ALVIN, designer, International Harvester Corp., *Chicago.*

PERLSTEIN, I. N., representative, Great Western Smelting & Refining Co., *Chicago.*

PIEL, R. A., assisting engineer, Rainier Motor Corp., *Flushing, N. Y.*

PLUMB, HAROLD B., secretary, Iowa Dairy Separator Co., *Waterloo, Iowa.*

POLLOCK, RAYMOND C., material inspector, Standard Steel Car Co., *Butler, Pa.*

SAWDEY, NEIL T., chief engineer, Weger Motor Co., *Cleveland.*

SCHADE, HERMAN P., president, The Bearings Company of Penn., Inc., *Philadelphia.*

SCHLEININGER, HARRY F., general sales manager, The Motor Car Equipment Co., *New York.*

SCHROETER, BRUNO, checker, Hupp Motor Car Corp., *Detroit.*

SHULER, FRANK A., president, Shuler Axle Mfg. Co., *Detroit.*

SMITH, HERBERT M., assistant service engineer, The Aluminum Castings Company, *Cleveland.*

SMITH, NOAH, *Sanangelo, Tex.*

SMITH, ROBERT L., inspector, Gray & Davis, Inc., *Boston.*

SMITH, SYDNEY CYRIL, service manager, Stults Motors Co., *Ft. Wayne, Ind.*

SONNEK, P. FRANK, officer and director, Manufacturers Equipment Co., *New York.*

STANDIFORD, FRED A., chief engineer, Standiford Two Stage Valveless Motor Co., *Kansas City, Mo.*

STALB, ARTHUR ROLSTAN, aeronautic draftsman, U. S. Navy Aeronautic Station, *Pensacola, Fla.*

STRATTON, JOHN F. D., manager, Standard Ignition Co., *Elkhart, Ind.*

SWEET, GEORGE W., general manager, Champion Wagon Company, *Owego, N. Y.*

TAGGART, FRANCIS F., inspector of airplanes and airplane engines, Signal Service at Large, *Buffalo.*

TAVENER, CHARLES H., student, Mass. Institute of Technology, *Cambridge, Mass.*

TEETSOW, W. H., chief engineer, U. S. Ball Bearing Mfg. Co., *Chicago.*

TEMPLEMAN, R. B., automobile draftsman, Jordan Motor Car Co., *Cleveland.*

TEMPLIN, ELLIS W., assistant chief engineer, Selden Motor Vehicle Co., *Rochester, N. Y.*

TUCKER, GORDON E., road engineer, Zenith Carbureter Co., *New York.*

VAN DYKE, JAMES RICHARD, student, Penn. State College, *State College, Pa.*

WALKER, KARL FORD, automobile engineer, U. S. Government, Q. M. G. Office, War Dept., *Washington, D. C.*

WALSH, EMMET I., chief draftsman, Abbott Corp., *Cleveland.*

WARD, JOSHUA, experimental mechanical engineer, Standard Aero Corp., *Plainfield N. J.*

WARD, LOUIS M., manager, Cushman Motor Works, *Lincoln, Neb.*

WARNER, ARCHIBALD A., Cleveland manager, Zenith Carburetor Co., *Cleveland.*

WATERMAN, C. B., president, Waterman Motor Company, *Detroit.*

WATSON, JOHN MITCHELL, metallurgist, Hupp Motor Car Corp., *Detroit.*

WELLES, HOWARD W., engineering department, Commercial Truck Co. of America, *Philadelphia.*

WELSH, WILLIAM E., salesman, McKinney Curtis Co., *Fargo, N. D.*

WESTBURY, HARRY, sales manager, H. W. McCandless Co., *New York.*

WHITE, PERCIVAL W., automobile expert, Ordnance Department, Rock Island Arsenal, *Rock Island, Ill.*

WOLFF, RUDOLPH D., efficiency engineer, Yellow Cab Company, *Chicago.*

ZIMMERMAN, JAMES GARFIELD, service engineer, Sumter Electrical Co., *Chicago.*

Applicants *Qualified*

The following list of applicants have qualified for admission to the Society between September 19 and October 17.. The various grades of membership are indicated by (M) Member; (A) Associate Member; (J) Junior; (Aff.) Affiliate; (Aff. Rep.) Affiliate Representative; (S. E.) Student Enrollment.

ACKER, EMIL W. (M) representative, spring engineer, Sheldon Axle & Spring Co., *Wilkesbarre, Pa.,* (mail) 1203 Bender Ave., *Cleveland.*

AHRENS, HARRY A. (A) branch sales manager, Nordyke & Marmon Co., *Indianapolis,* (mail) 1608-10 McGee St., *Kansas City, Mo.*

ANDERSON, DOUGLAS G. (A) general manager, Cyclemotor Corp., *Rochester, N. Y.,* (mail) 261 Post Ave.

ARCHIBALD, J. R. (A) district salesman, Maxwell Motor Car Co. of Canada, *Windsor, Canada,* (mail) Room 46, Y. M. C. A., *Regina, Sask., Can.*

ARMSTRONG, FREDERICK S. (A) advertising manager, Vesta Accumulator Co., 2100 Indiana Ave., *Chicago,* (mail) 523 Clarence Ave., *Oak Park, Ill.*

AUGENSTEIN, W. C., JR. (A) sales engineer, Vesta Accumulator Co., 2100 Indiana Ave., *Chicago,* (mail) 2251 Sheffield Ave.

BALDWIN, JOHN (A) branch manager, solid tire department, Kelly-Springfield Tire Co., Cleveland, (mail) 2251 S. Michigan Ave., *Chicago.*

BALSOM, JOHN J. (M) production manager, Harley-Davidson Motor Co., *Milwaukee, Wis.*

BANNISTER, H. B. (A) secretary-treasurer, Muncie Wheel Co., *Muncie, Ind.*

BASSETT, W. H. (M) technical superintendent, metallurgist, The American Brass Co., *Waterbury, Conn.*

BEAN, R. M. (A) sales manager, Durston Gear Co., Inc., *Syracuse, N. Y.*

BIJUR, HARRY (A) attorney at law, Trego Motors Corp., *New Haven, Conn.,* (mail) 120 Broadway, *New York.*

BIRCKELBOW, LLOYD (S.E.) specializing in gas engineering, University of Michigan, *Ann Arbor, Mich.,* (mail) 616 E. Huron St.

BIRNEY, E. H. (M) manager, treasurer, The Peerless Drawn Steel Co., *Massillon, Ohio.*

BLAKESLEE, C. J. (M) assistant chief engineer, Woods Motor Vehicle Co., *Chicago,* (mail) 1523 E. 66th Place.

BLEAKLEY, P. A. (A) district manager, King Motor Car Co., *Detroit,* (mail) 710 Van Ness Ave., *San Francisco.*

BONHAM, W. R. (A) Chicago sales manager, Triumph Electric Co., *Cincinnati,* (mail) 327 S. LaSalle St., *Chicago.*

BOURQUARDEZ, A. C. (A) vice-president, sales manager, General Vehicle Co., Long Island City, N. Y.

BOWKER, HAROLD G. (A) chief draftsman, Four Wheel Drive Auto Co., *Clintonville, Wis.,* (mail) Box 564.

BRANFIELD, R. H. B. (Aff. Rep.) engineer, The New Way Motor Co., *Lansing, Mich.*

BREITSCHMID, assistant service manager, Bosch Magneto Co., 223 W. 46th St., *New York,* (mail) 809 Melrose Ave.

BRATE, HARRY R. (M) secretary, National Gas Engine Association, *Lakemont, N. Y.*

BROOKMAN, LOUIS (A) western representative, The Commercial Vehicle, *New York,* (mail) 2105 Mallers Bldg., *Chicago.*

BROWN, IRL C. (S.E.) P. O. Box 252, *Clarksville, Tenn.*

BUSH, J. H. (A) president, Bush Motor Co., Bush Bldg., *Chicago.*

CAMPBELL, LEON J. (M) chief engineer, Campbell Transmission Co., *Buchanan, Mich.*

CARLSON, CHAS. A. (M) motor efficiency expert, district manager, Troy Trailer Co., *Troy, Ohio,* (mail) 505 Riggs Bldg., *Washington, D. C.*

CARHART, GEORGE C. (M) designer, Brown-Lipe Gear Co., *Syracuse, N. Y.,* (mail) 109 Elmwood Ave.

CHASE, A. M. (M) president, engineer, Chase Motor Truck Co., *Syracuse, N. Y.,* (mail) 508 University Place.

CLYDE CARS CO., THE (Aff. Mem.) Clyde, Ohio. Representative: J. B. Crockett, treasurer, 44 Whitehall St., *New York.*

COFFMAN, DON M. (A) traveling salesman, Wetzel-Hall Co., 33 W. 42d St., *New York.*

CROCKETT, J. B. (Aff. Rep.) treasurer, Clyde Cars Co., 44 Whitehall St., *New York.*

DAIN, JOSEPH, JR. (A) special experimental bureau, Deere & Co., *Moline, Ill.*

DASHIELL, W. W. (M) president, N. Y. Lubricating Oil Co., 116 Broad St., *New York.*

DEJARNEY, CAPT. M. E. (M) technical manager, The British Motor Cab Co. 111 Grosvenor Road, *London, S. W., England,* (mail) care of French Commission, 2001 Columbia Road, *Washington, D. C.*

DE LA GRANGE, CAPTAIN AMAURY (M) 1623 28th St., *Washington, D. C.*

DEMOTT, RICHARD HOOPER (A) sales engineer, S. K. F. Ball Bearing Co., 1 Wall St., *New York.*

DIFFIN, C. W. (A) manager Erie Specialty Co., *Erie, Pa.*

DRAY, WALTER R. (M) vice-president, general manager, Hart-Parr Co., *Charles City, Iowa.*

DUBBS, C. P. (A) consulting chemical engineer, 905 Greenleaf Ave., *Wilmette, Ill.*

DUNN, EDWARD J. (A) president, Eclipse Machine Co., *Elmira, N. Y.*

EISLE, WILLIAM STARK (J) draftsman, Pan-American Motors Corp., *Decatur, Ill.,* (mail) 1093 West Wood St.

ELWOOD, A. L. (A) branch manager, Nordyke & Marmon Co., *Indianapolis* (mail) 1608-10 McGee St., *Kansas City, Mo.*

EVANS, POWELL (M) president. Globe Automatic Sprinkler Co., Schuylkill Ry. Co., Schuylkill Electric Co., Merchant & Evans Co., 2035 Washington Ave., *Philadelphia.*

FALLERIUS, HENRY GUSTAVE (M) mechanical and electrical engineer, motor truck department. American Express Co., 218 E. 44th St., *New York,* (mail) 4 Travers Ave., *Mamaroneck, N. Y.*

FIRESTONE, ROBERT JAMES (A) vice-president, Firestone Tire & Rubber Co., *Akron, Ohio.*

FLIEDNER, CARLYLE (M) editor, Electricity Magazine Corp., Monadnock Bldg., *Chicago.*

FOWLER, HARLAN D. (J) aeronautical engineer, Aircraft Engineering Division, U. S. Government, 119 D St. N. E., *Washington, D. C.,* (mail) 130 B St. N. E.

GARNER, ORLO F. (A) chief draftsman, Marvel Carburetor Co., *Flint, Mich.,* (mail) 717 Cornelia St.

GLASS, F. E. (A) sales representative, The Oakes Co., Roosevelt Ave. & Belt R. R., *Indianapolis.*

GOODNOW, E. W. (Aff. Rep.) secretary, general manager, The New Way Motor Co., *Lansing, Mich.*

GROTHE, WALTER (M) engineer, The C. L. Best Gas Traction Co., *San Leandro, Cal.*

GURNEY, FREDERICK W. (M) chief engineer, Gurney Ball Bearing Co., *Jamestown, N. Y.* (mail) 1113 N. Main St.

HADLEY, WALTER K. (A) district sales manager, King Motor Car Co., *Detroit,* (mail) 309 W. 99th St., *New York.*

HALL, HENRY J., JR. (A) vice-president, manager, N. Y. Lubricating Oil Co., 116 Broad St., *New York.*

HARPER, H. F. (A) president, general manager, Prudden Wheel Co., *Lansing, Mich.*

HAWKE, C. E. (A) manager, Service Department, The Carborundum Co., *Niagara Falls, N. Y.*

HILL, E. K. (J) engine department, Thomas Morse Aircraft Corp., *Ithaca, N. Y.*, (mail) Y. M. C. A.

HOLMES, EDWARD W. (J) manager, Tozzi Mfg. Inc., 352 Pearl St., *New York*, (mail) 14 Botanic Place, *Flushing, N. Y.*

HOLT, PLINY EASTMAN (M) vice-president, The Holt Mfg. Co., *Stockton, Cal.*, (mail) 1520 N. Edwards St.

HOTZ, GEO. J. (M) president, mechanical engineer, The Hotz Foundry & Mfg. Co., *Fremont, Ohio.*

HOOF, ADDISON C. (A) sales engineer, W. K. Prudden Wheel Co., Lansing, Mich.; John C. Hoof & Co., *Chicago*, (mail) John C. Hoof & Co., 157 W. Illinois St., *Chicago.*

HOUSTON, GEO. H. (M) consulting engineer, Jamieson, Houston, Graham & Jay, Inc., 40 Wall St., *New York.*

ICKES, ELWOOD T. (M) special representative, Columbia Steel & Shafting Co., *E. Carnegie, Pa.*

IDE, ROY W. (M) gas engine designer, A. L. Ide & Sons, *Springfield, Ill.*

JANES, E. H. (A) vice-president, treasurer, Standard Steel Castings Co., *Cleveland.*

JOBSKI, OTTO H. (A) engineer, The Standard Parts Co., *Cleveland.*

JONES, D. W. (M) chief engineer, Diamond T Motor Car Co., 4517 W. 26th St., *Chicago.*

KEILHOLTZ, L. S. (M) chief engineer, Domestic Engineering Co., *Dayton, Ohio.*

KELLY, WILLIAM (Aff. Rep.) consulting engineer, Maxwell Motor Co., Inc., *Detroit.*

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